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Theory Group

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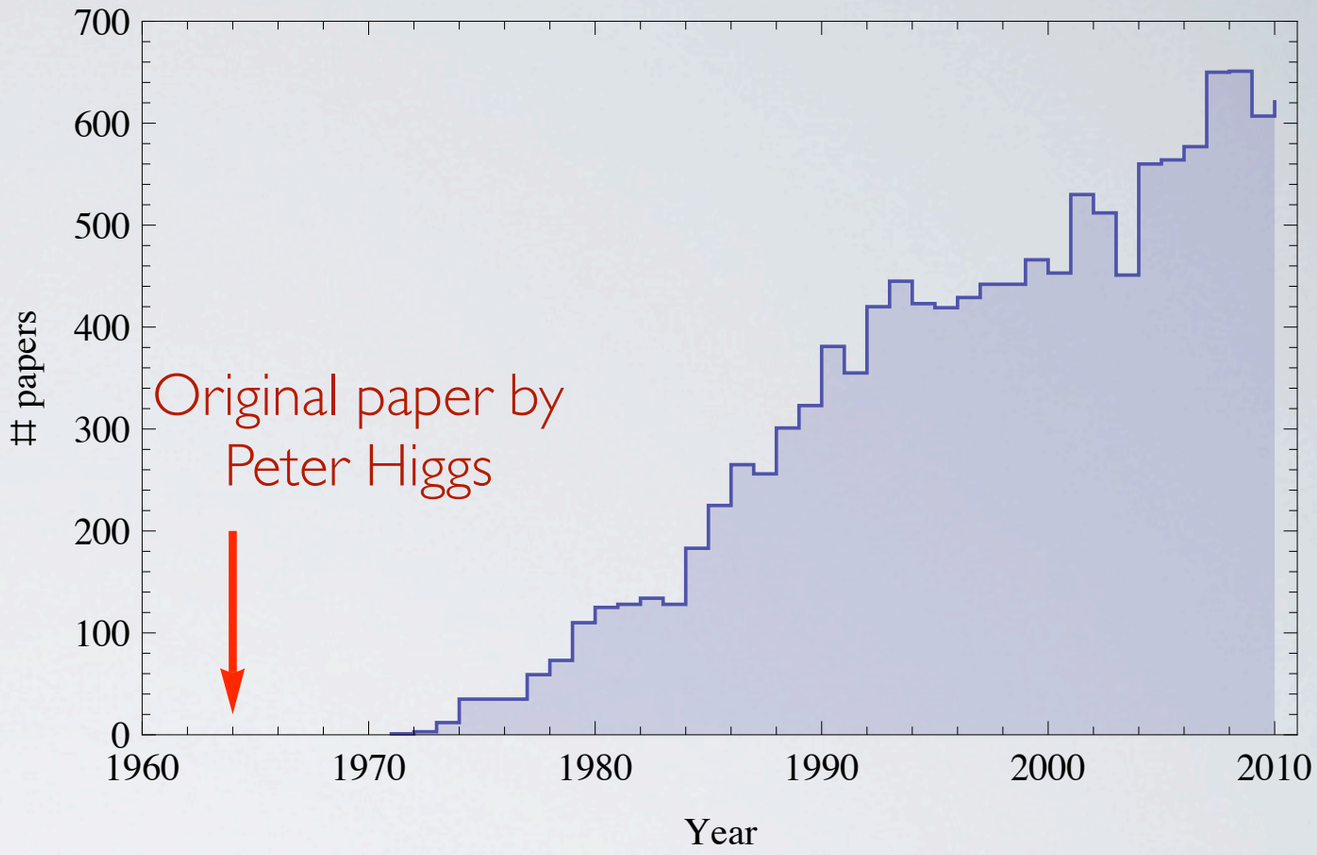
What's all the fuss about?



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Race for 'God particle' heats up

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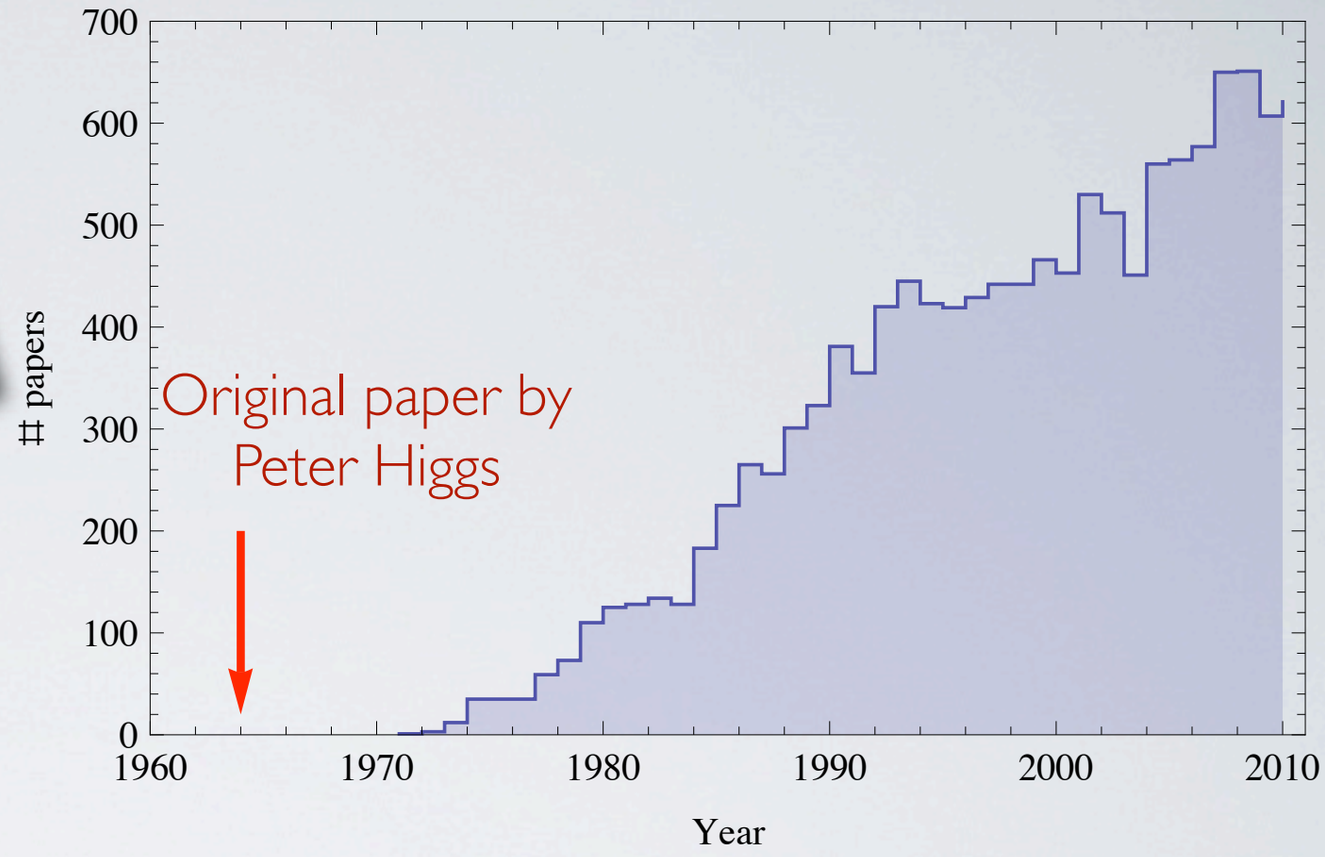

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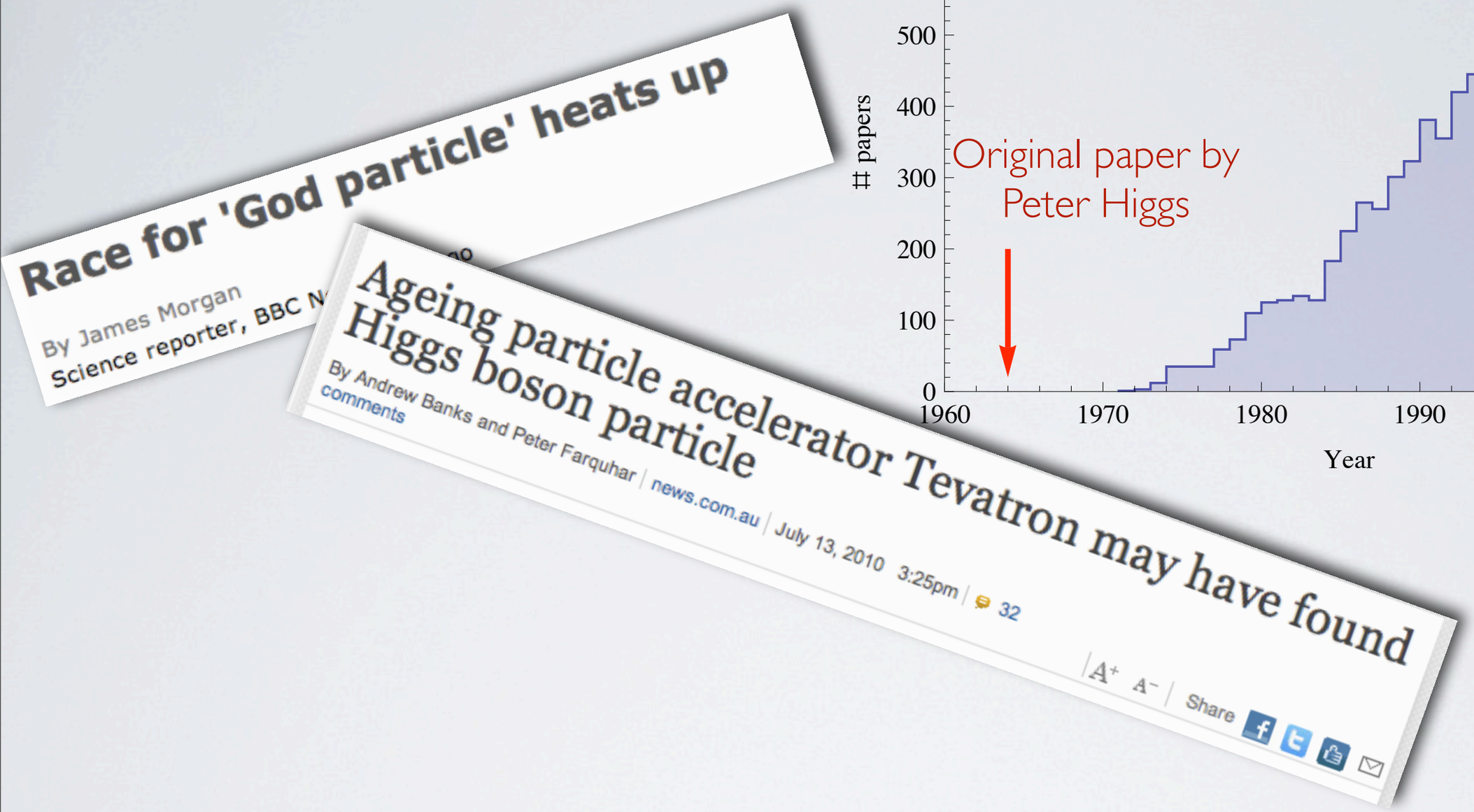

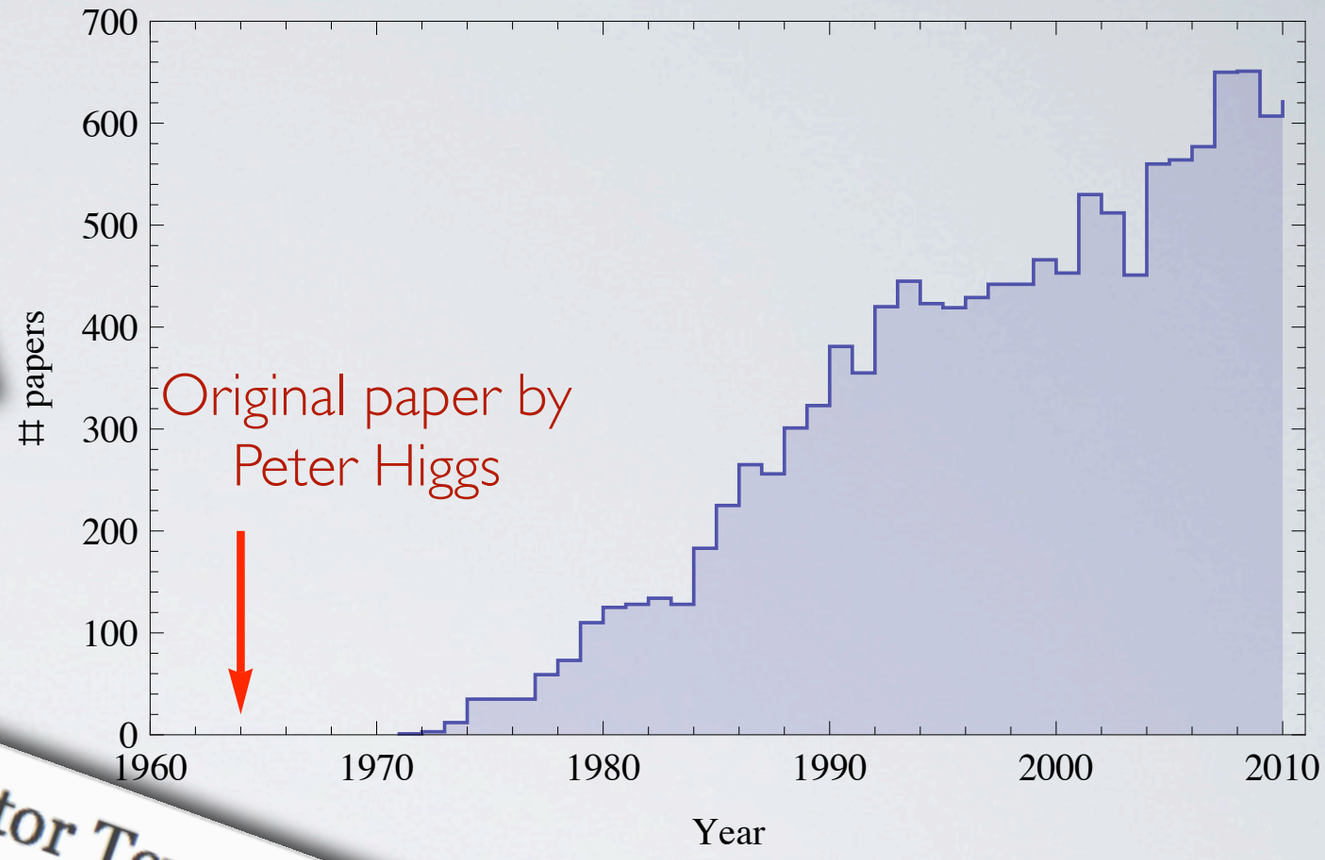

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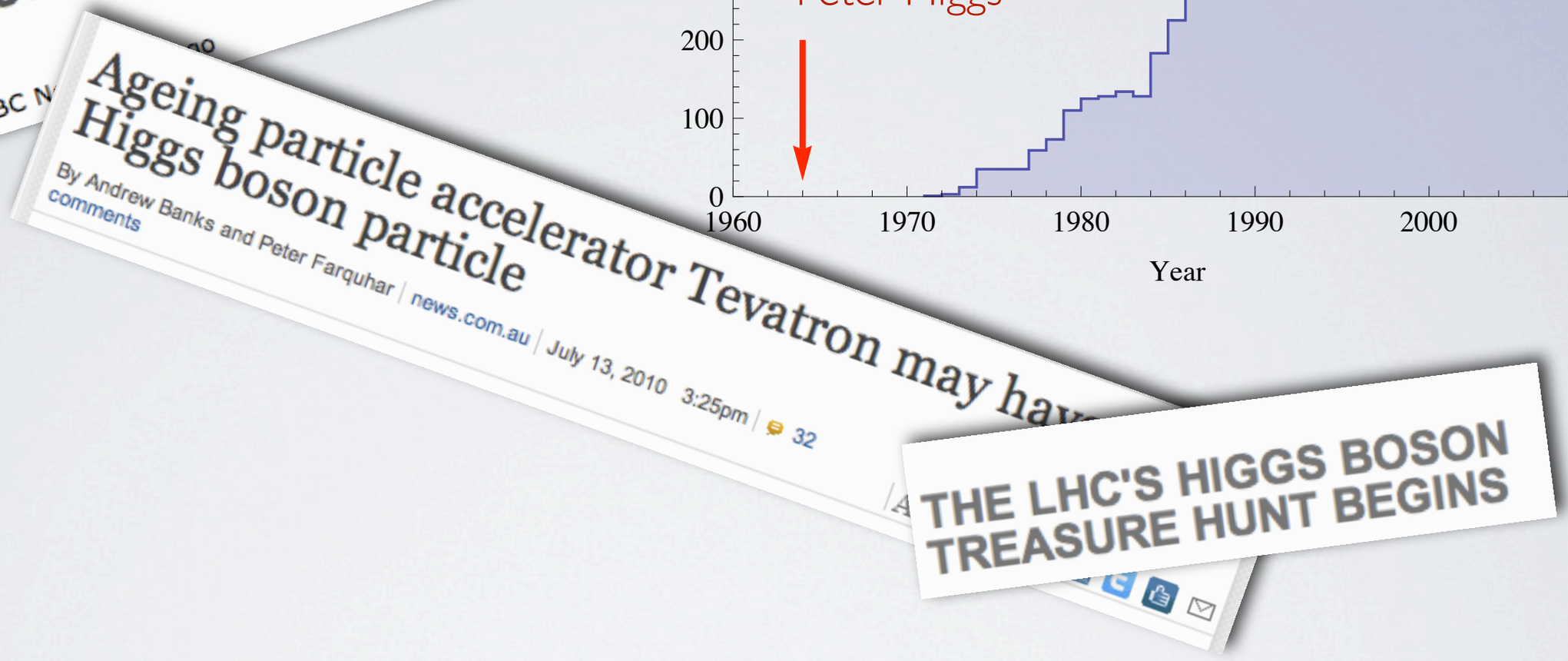

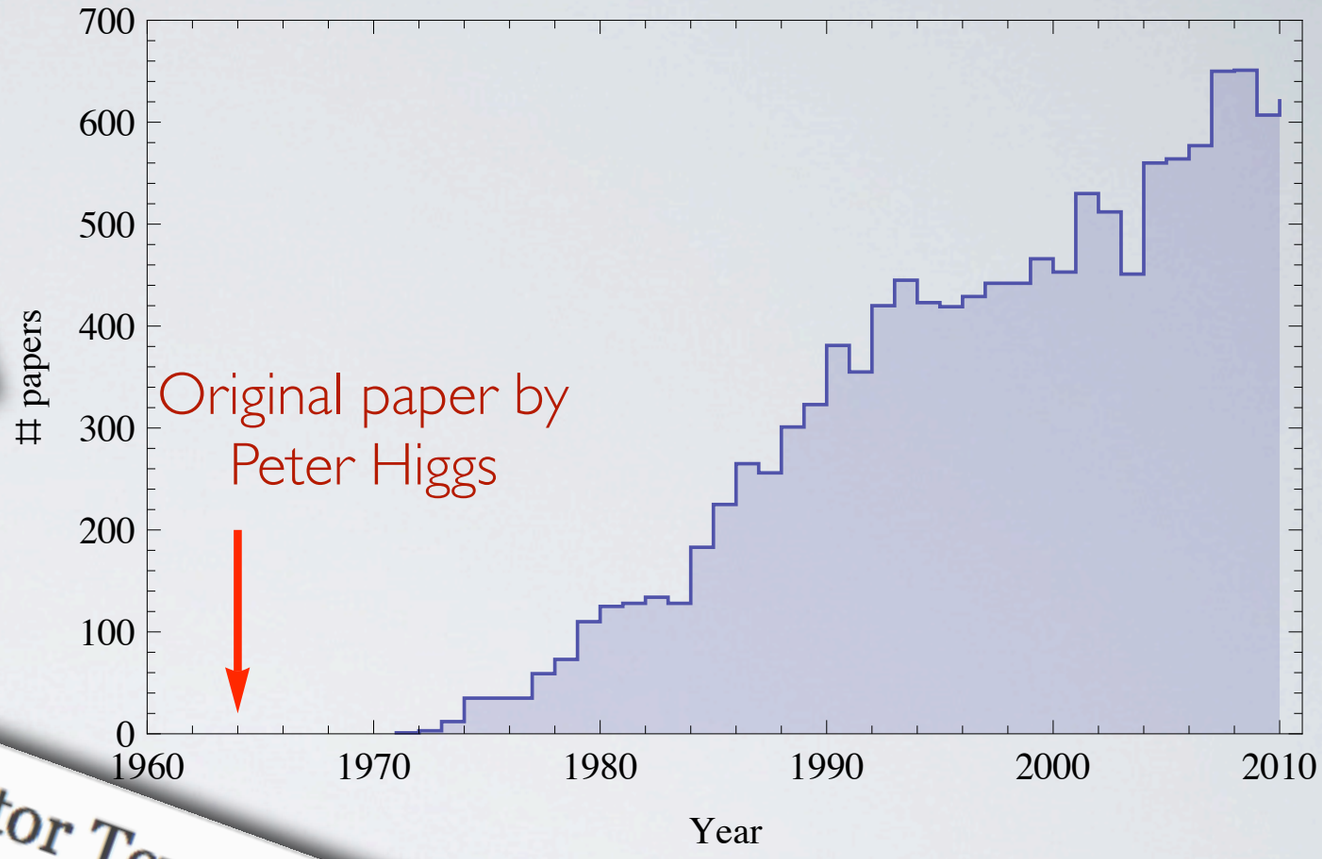

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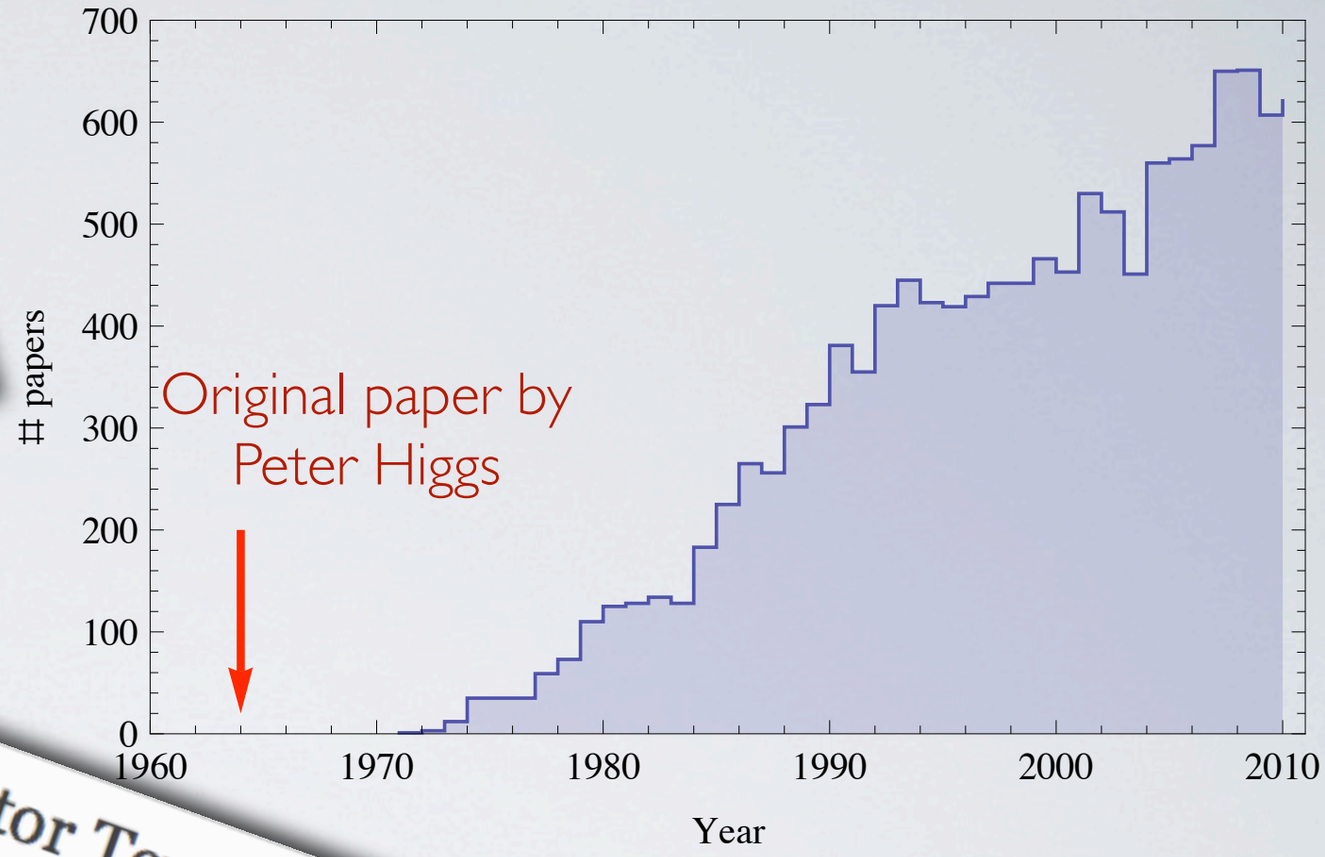

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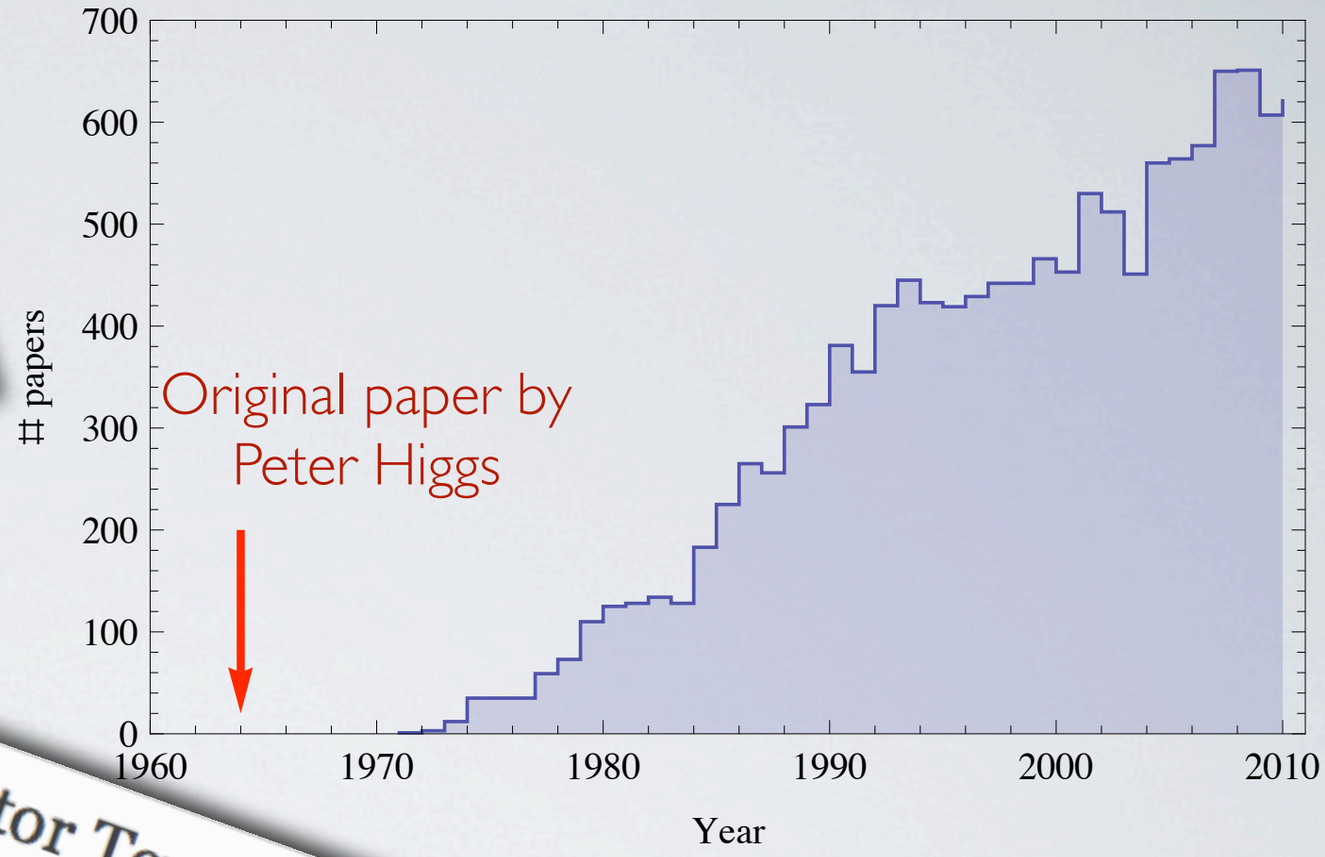

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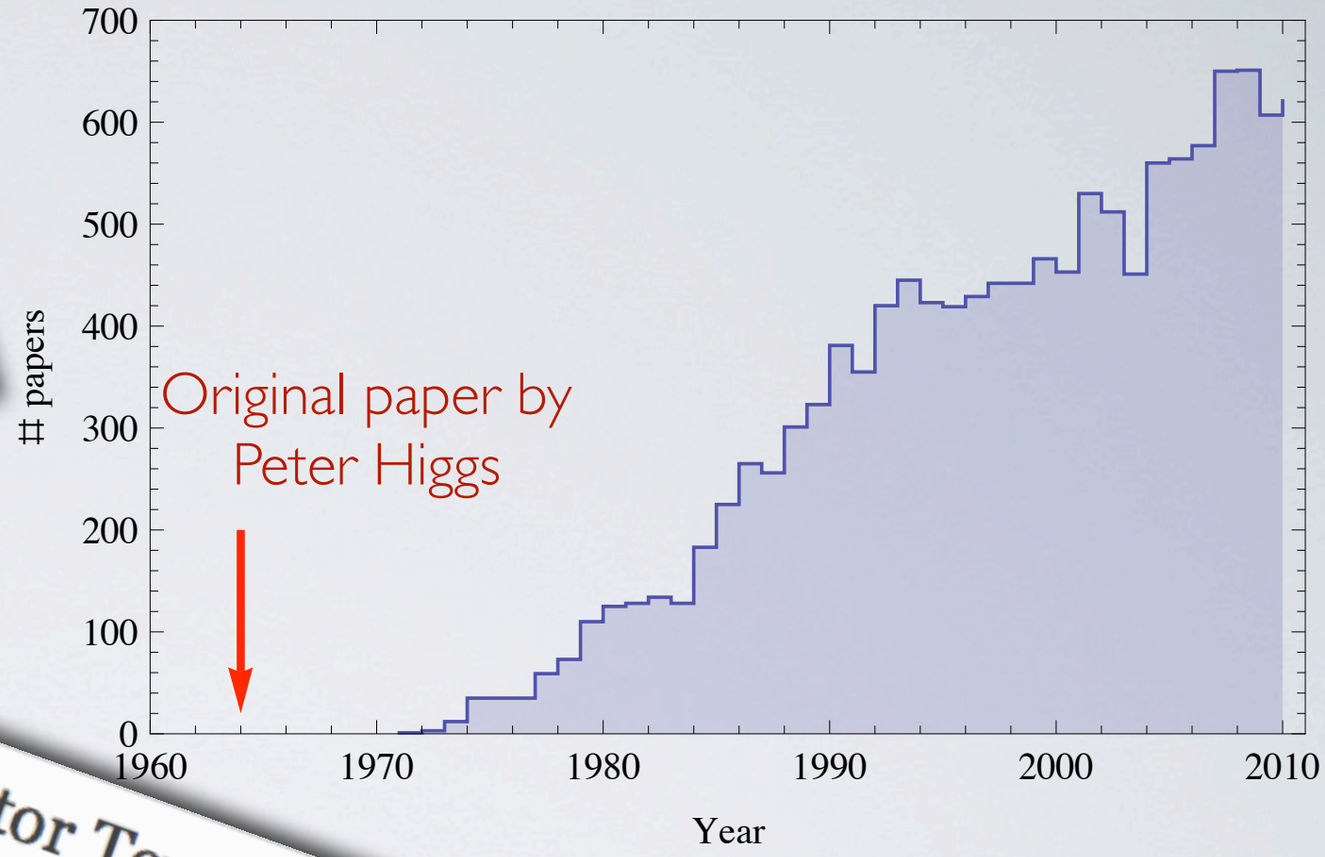

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Repaired too Late? Tevatron May Beat LHC in
for Higgs Boson

by IAN O'NEILL on FEBRUARY 18, 2009

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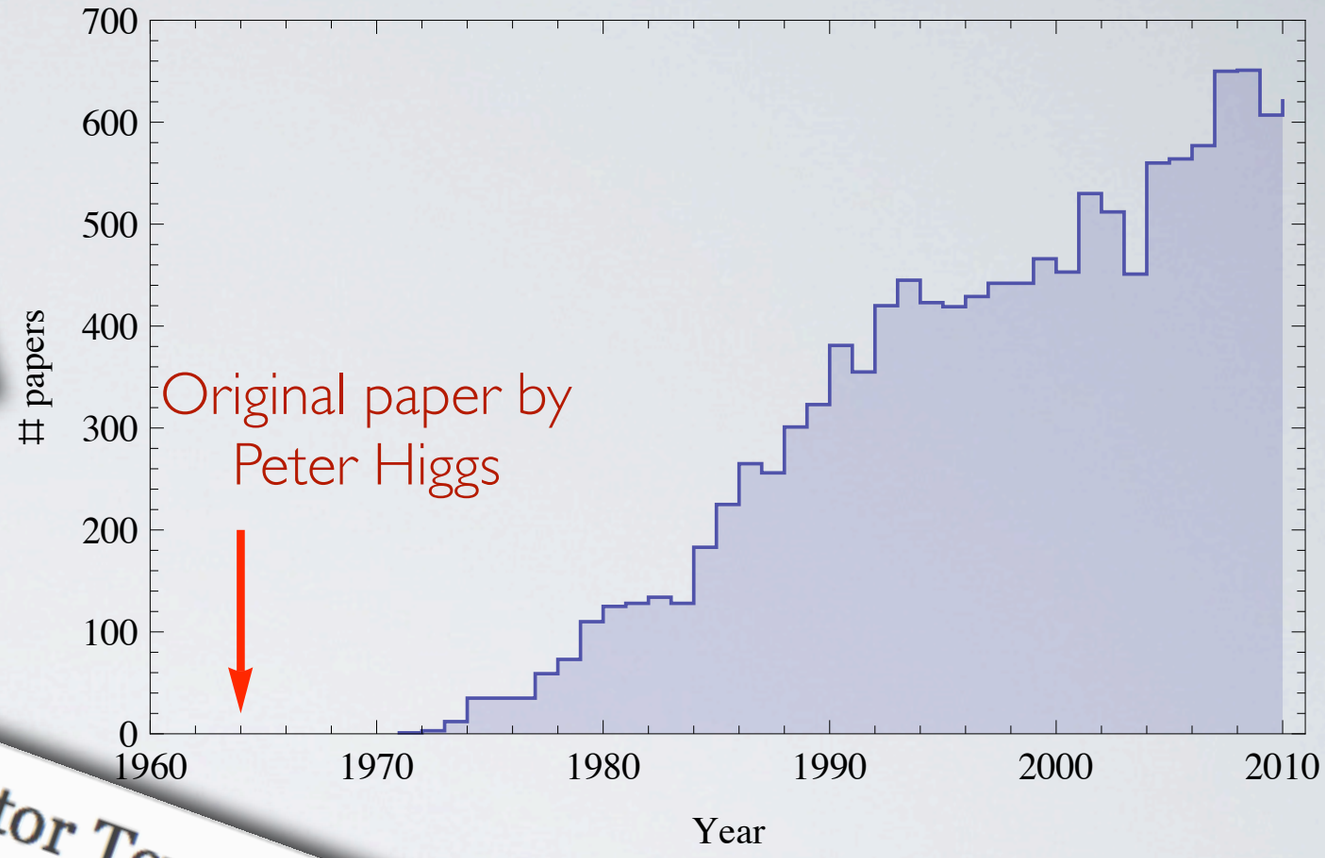

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23 July 2010 Last updated at 15:33 ET

LHC closes in on massive particle

By Paul Rincon
Science reporter, BBC News, Paris

Repair tron May Beat LHC in
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by IAN O'NEILL on FE

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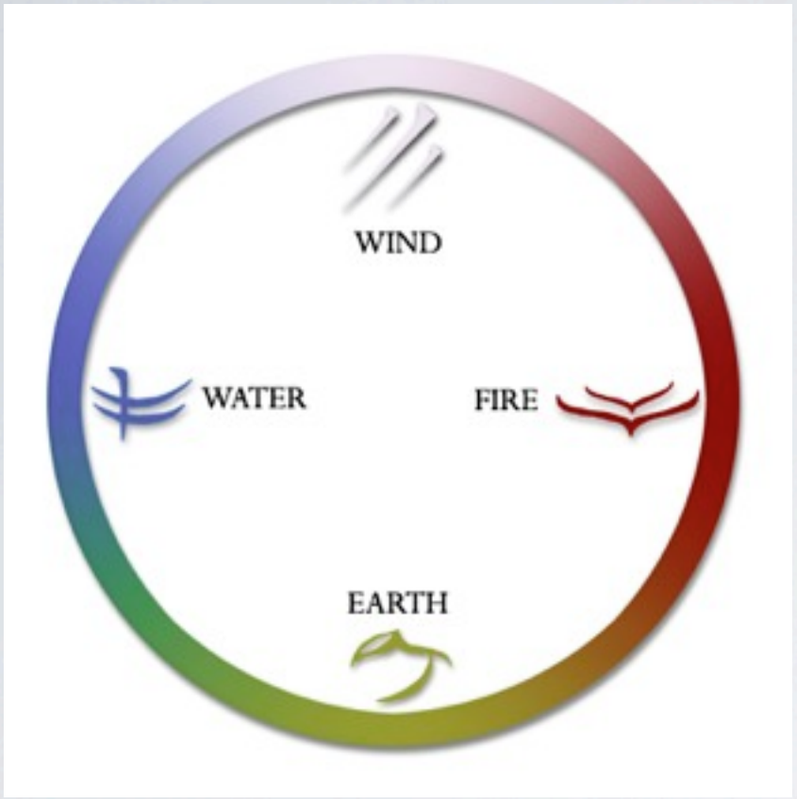

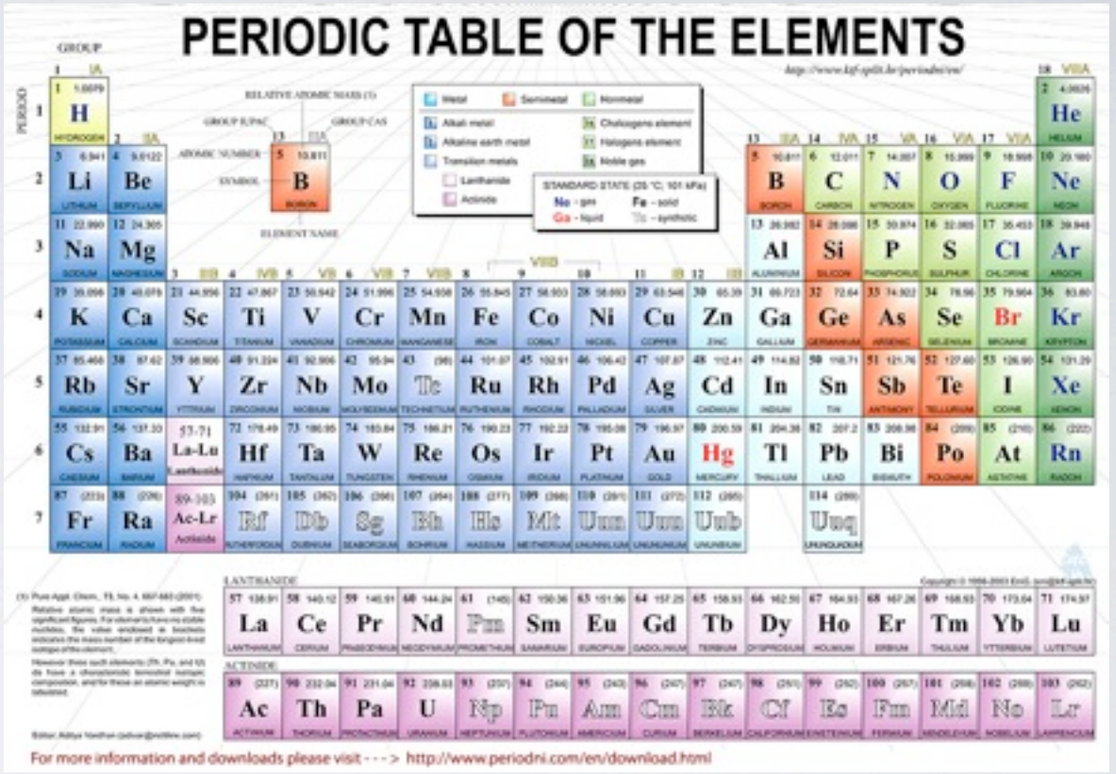

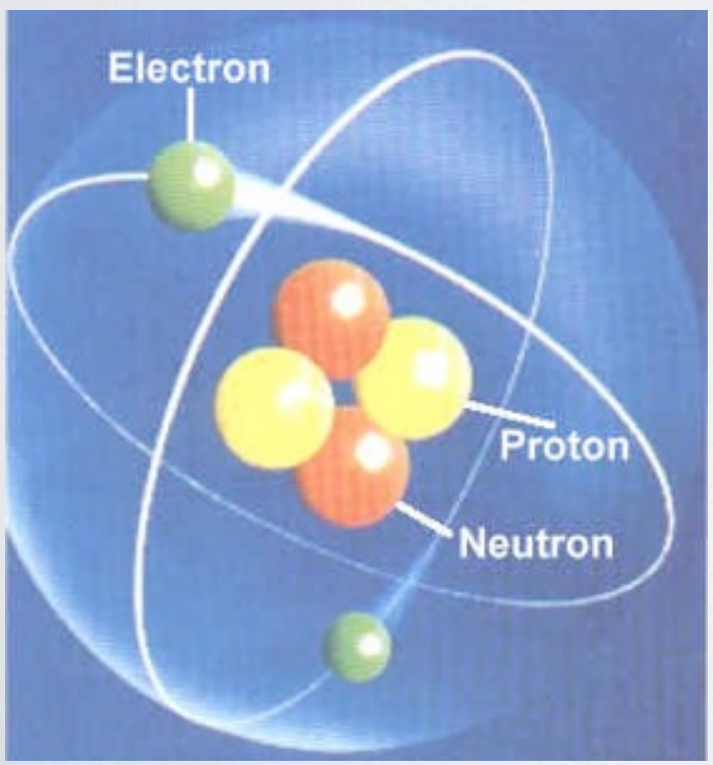

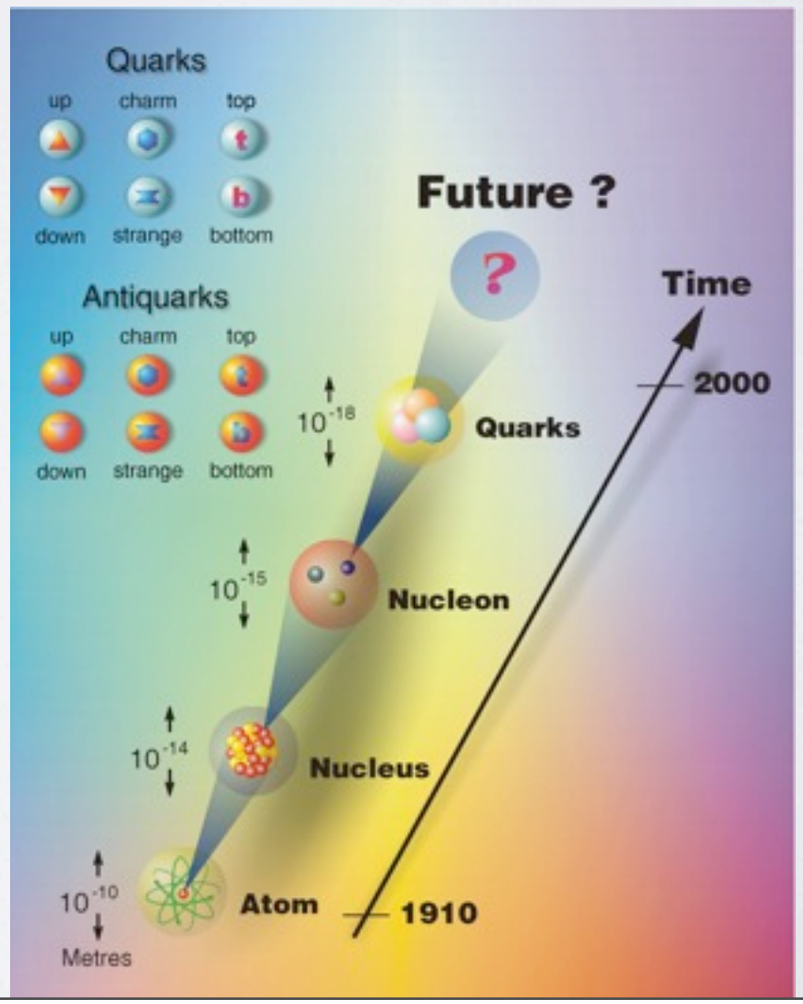

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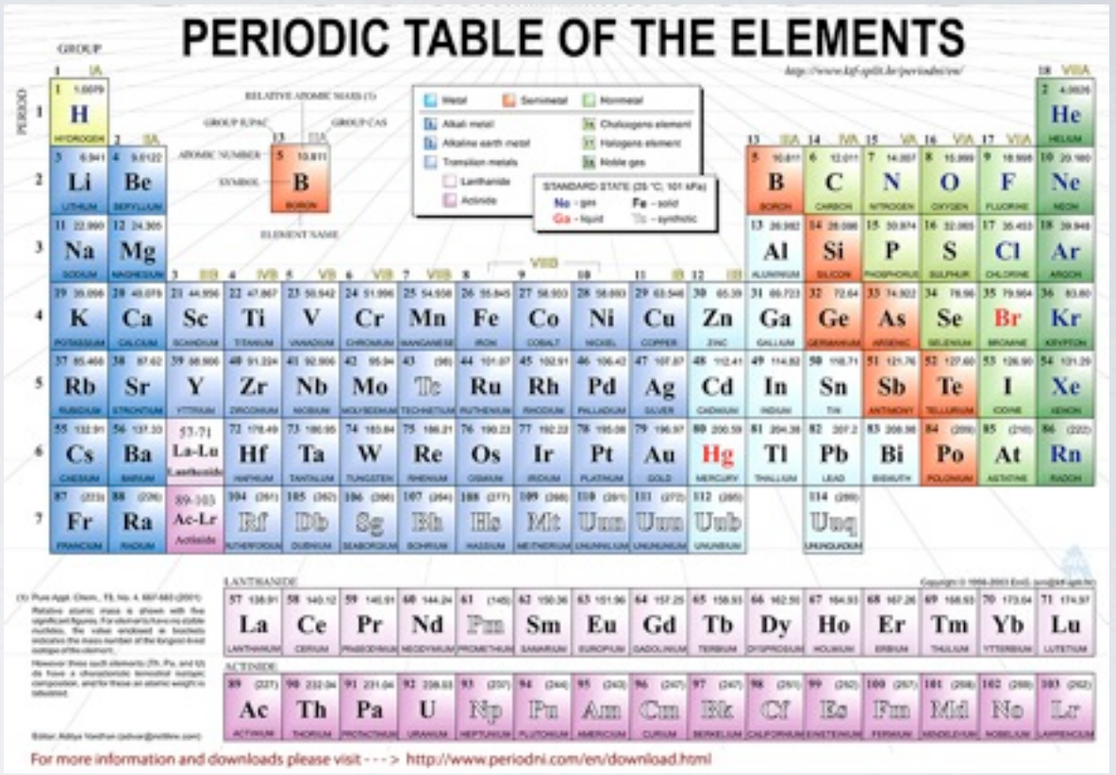

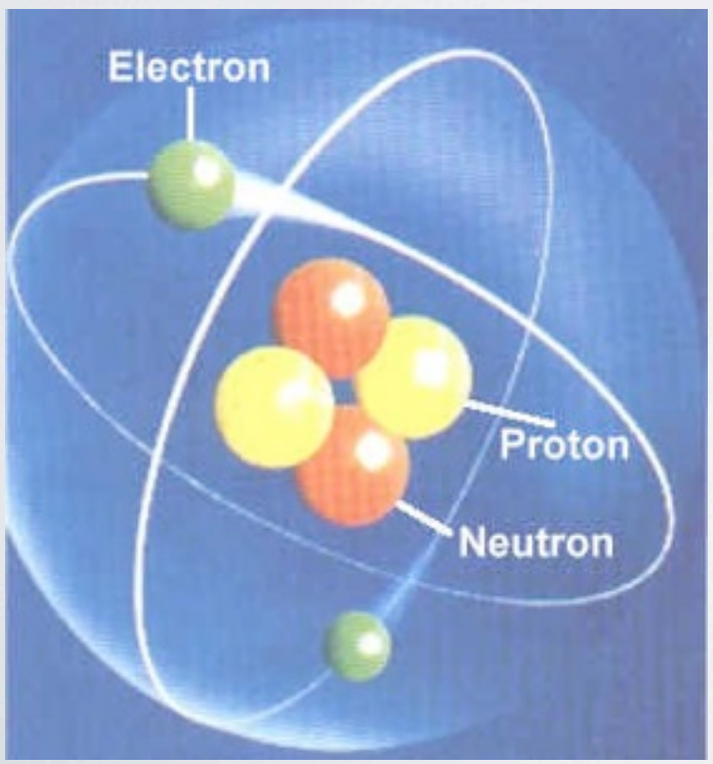

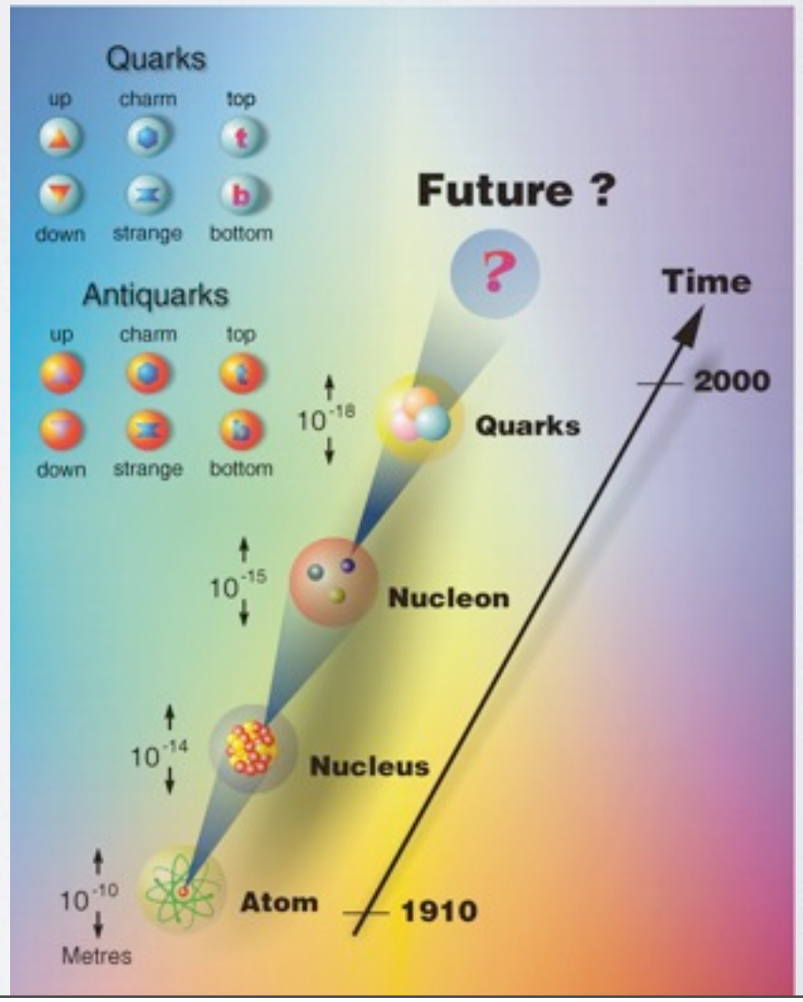

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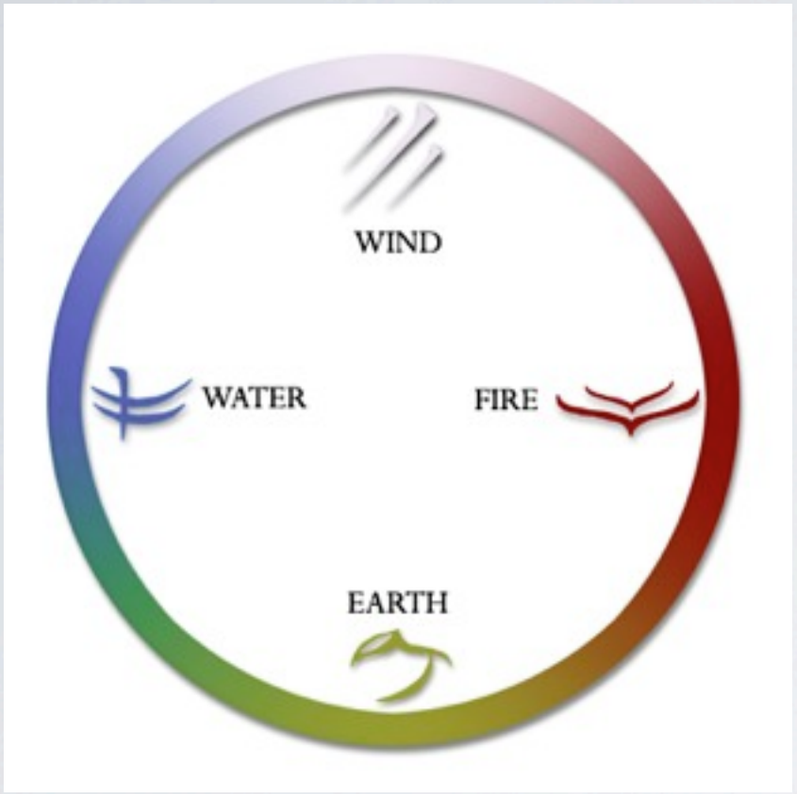

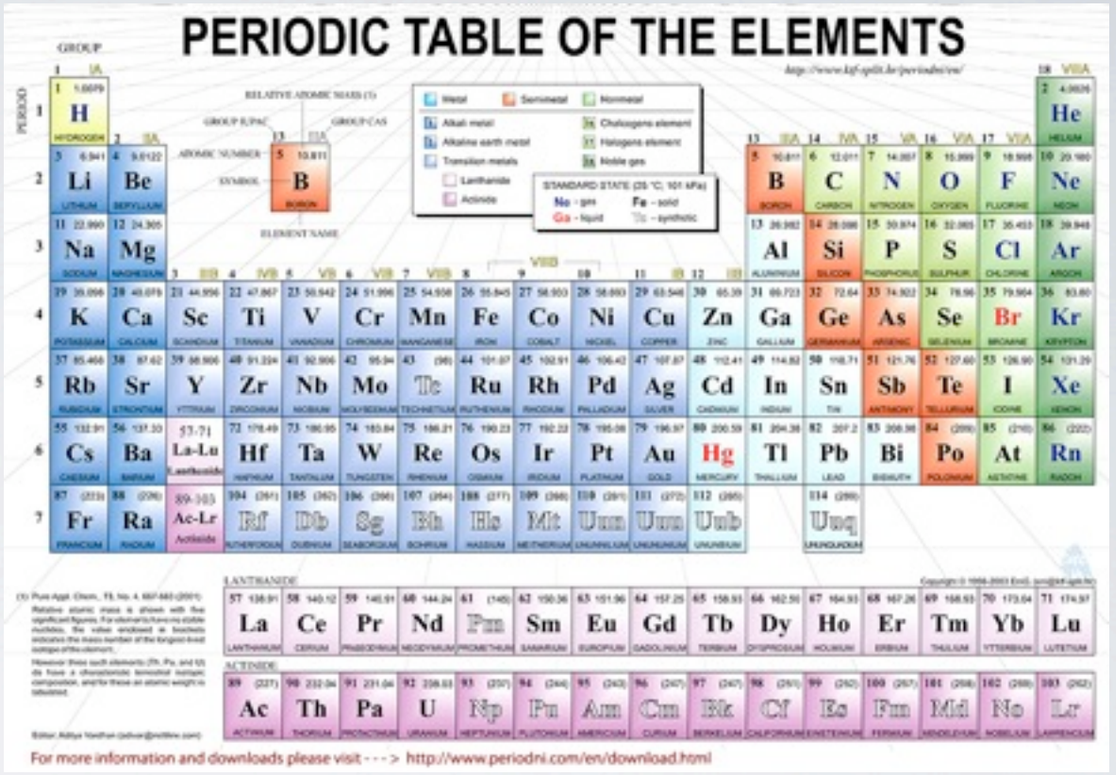

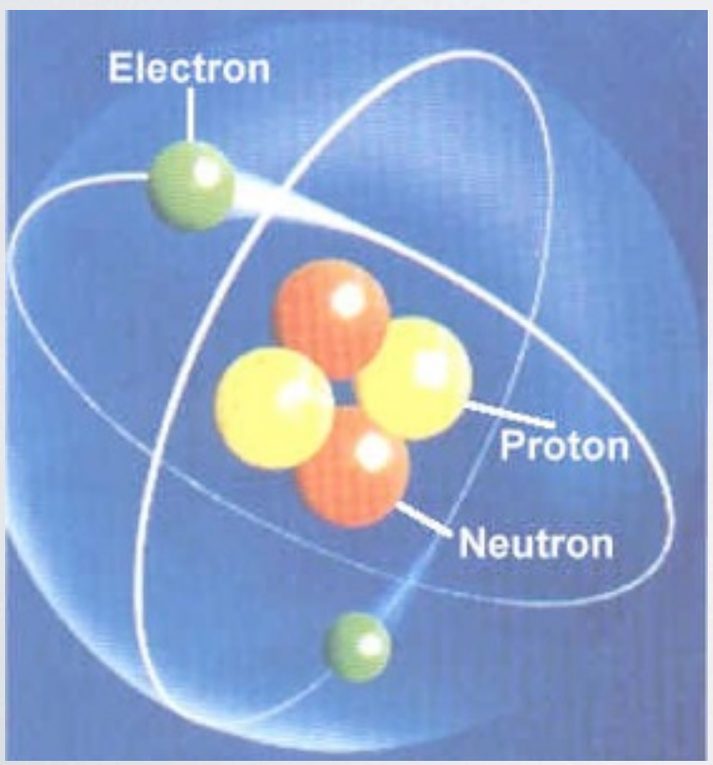

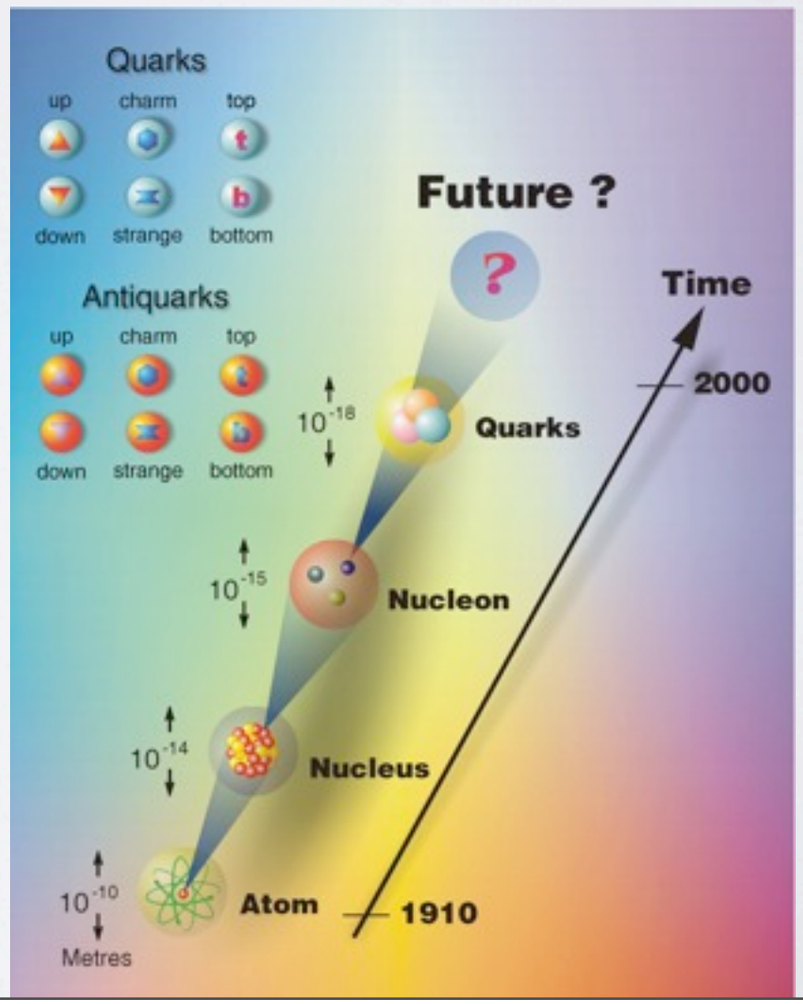

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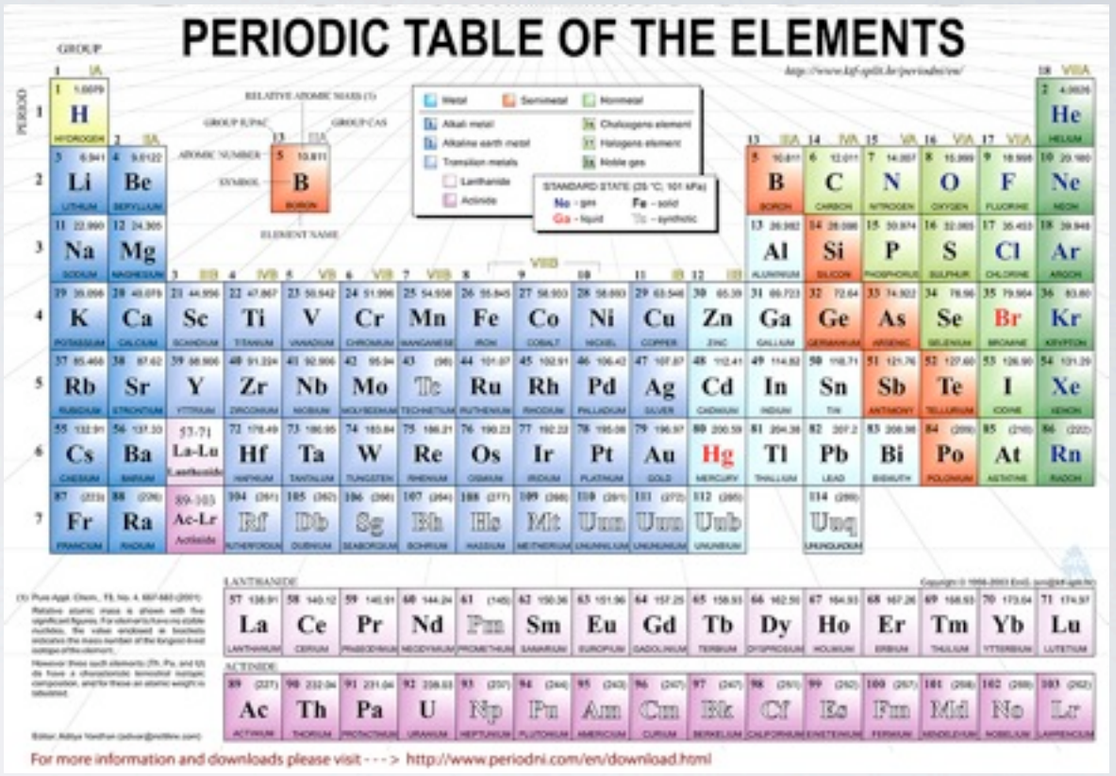
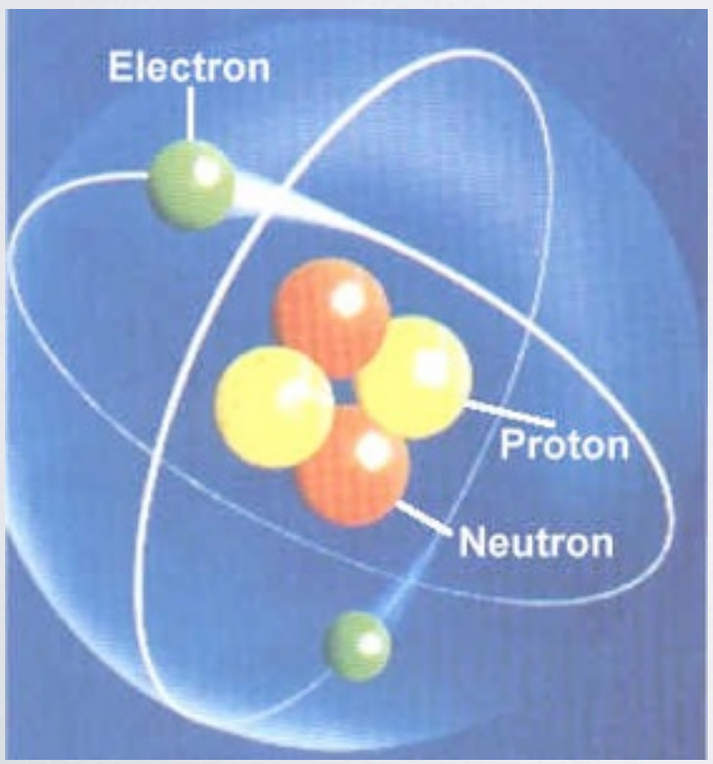
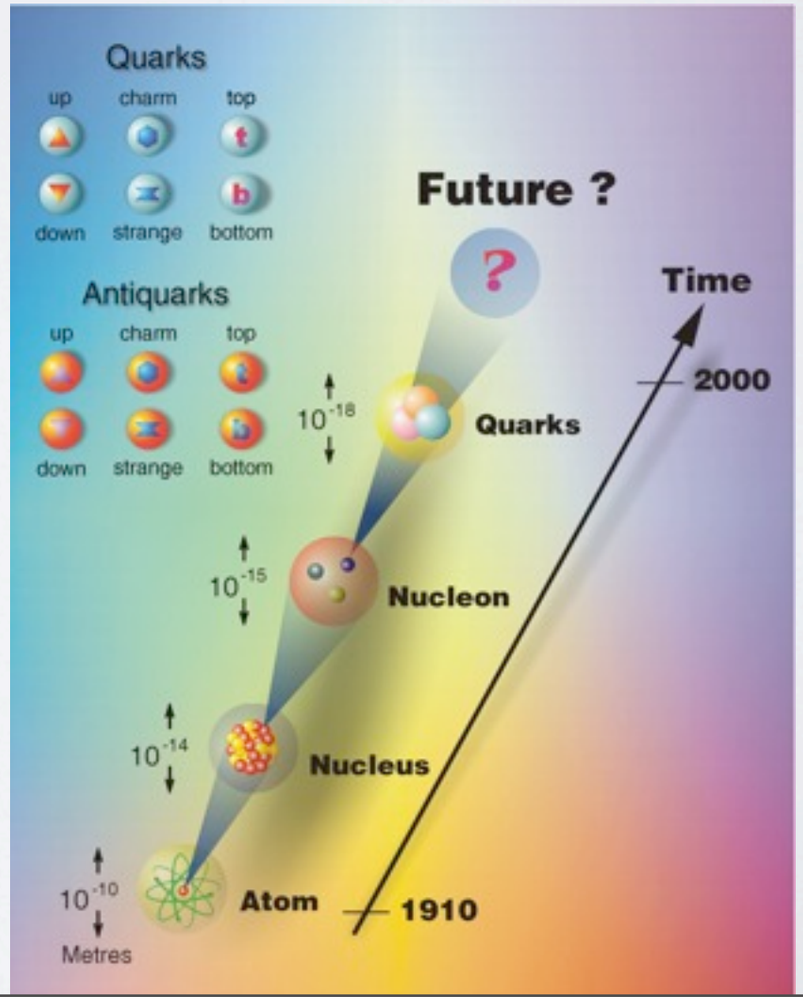
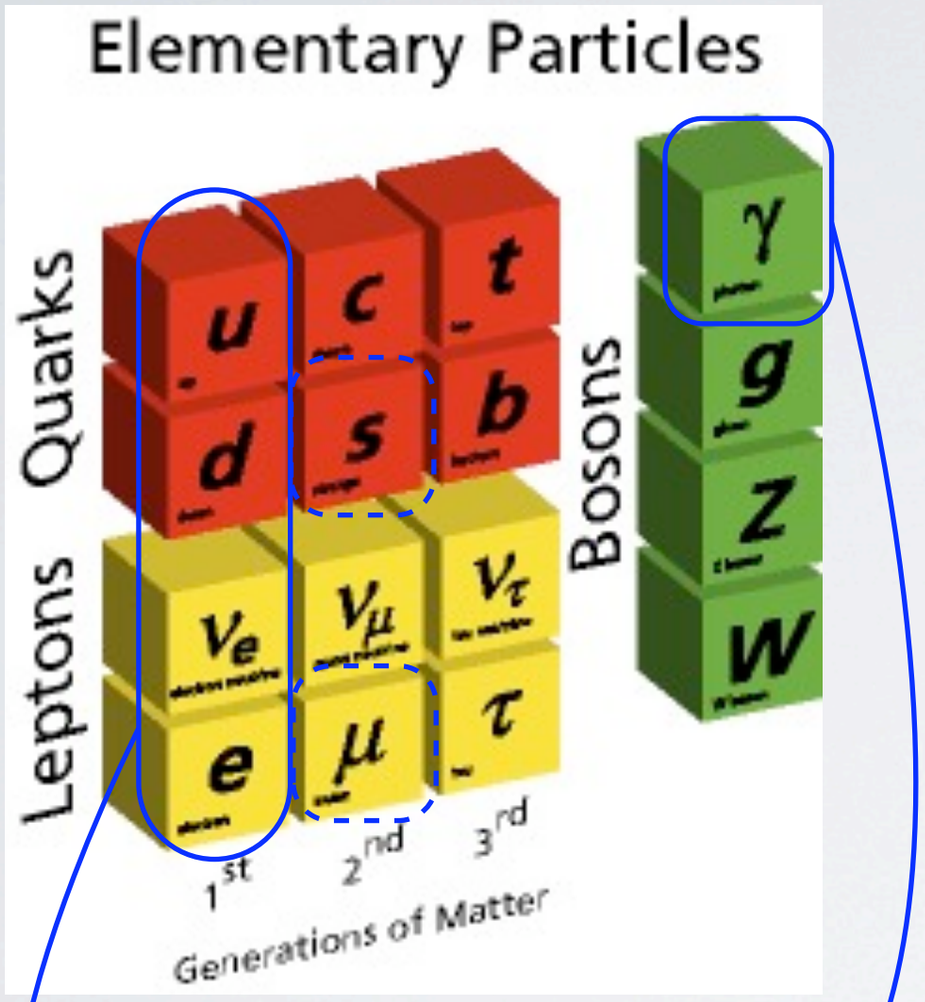




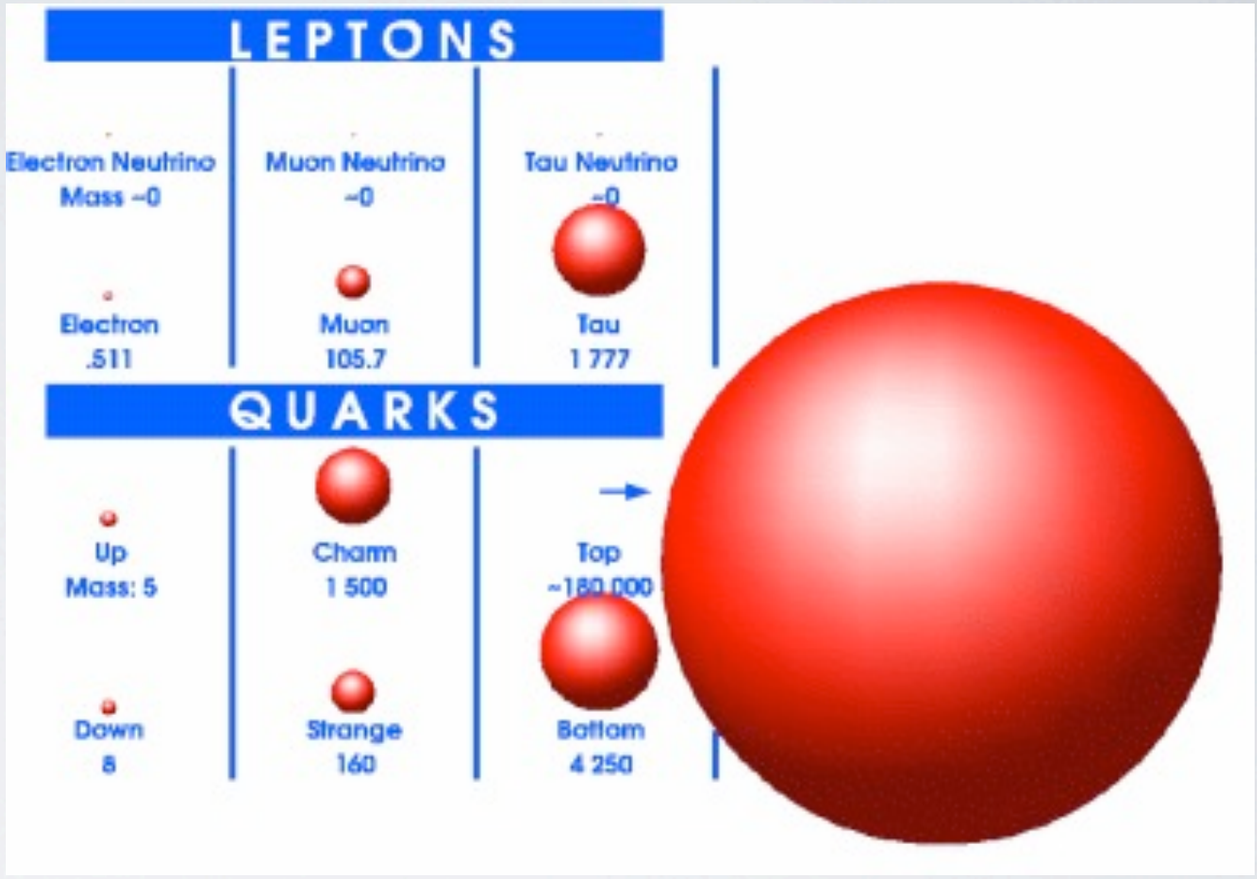


The building blocks of nature

(*the Standard Model*)



"Everyday" stuff



BOSONS force carriers spin = 0, 1, 2, …

Unified Electroweak spin = 1

Name	Mass GeV/c^2	Electric charge
γ photon	0	0
W^-	80.39	–1
W^+ W bosons	80.39	+1
Z^0 Z boson	91.188	0

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1 GeV = mass of proton

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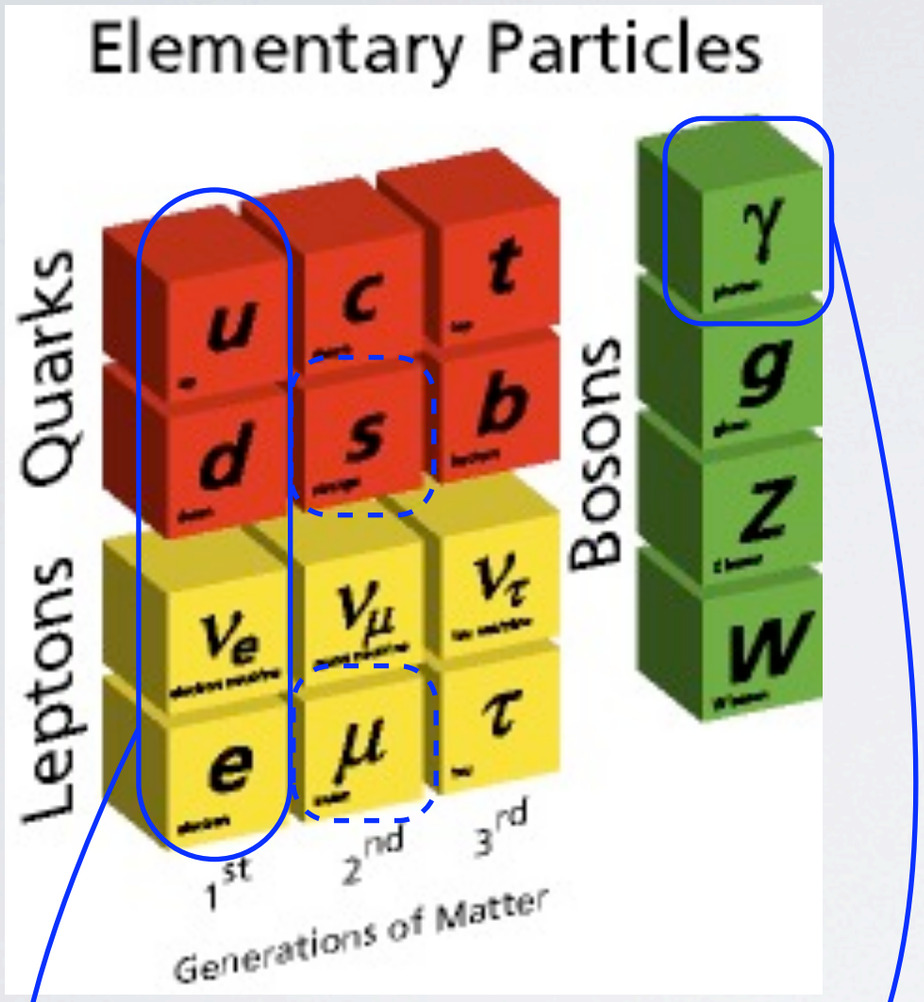
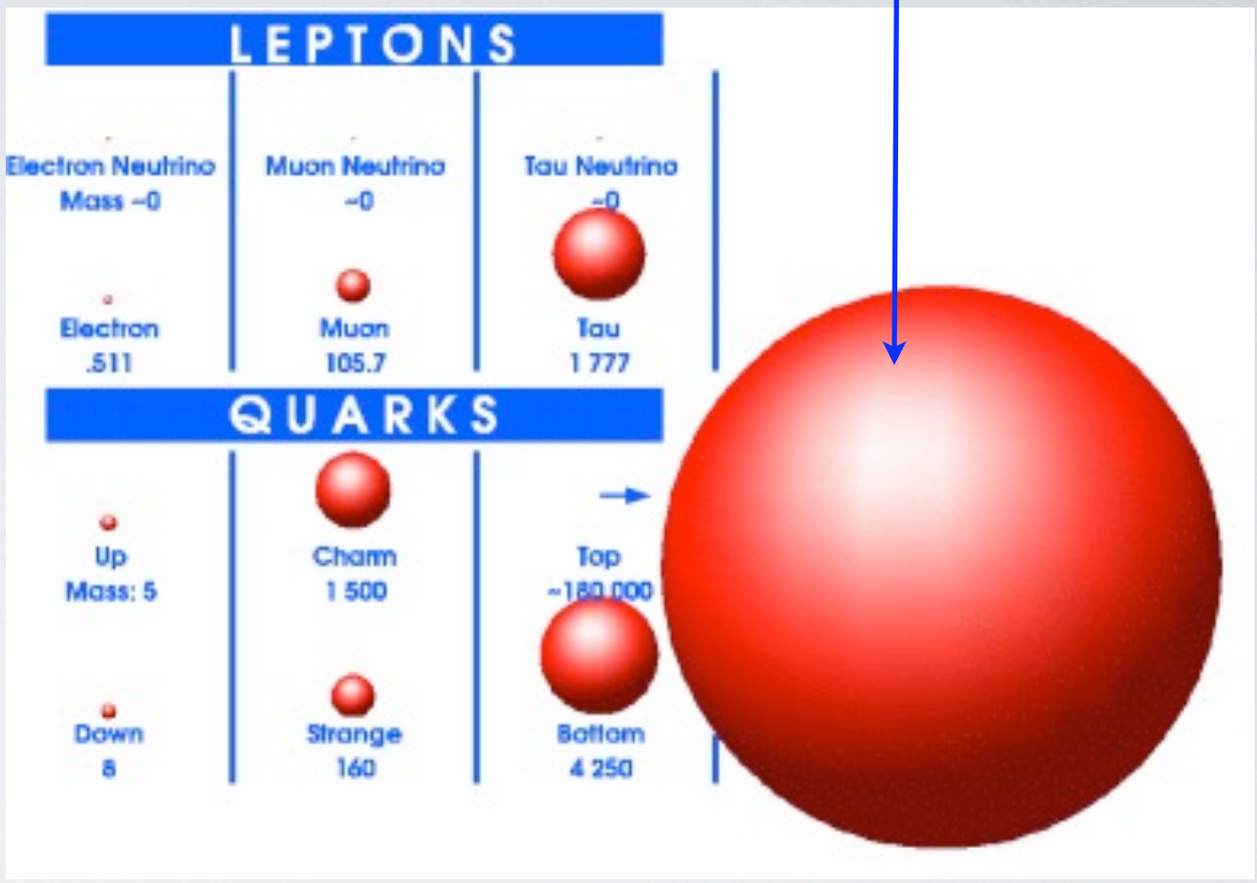


"Everyday" stuff

approx. mass of gold atom



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How the Z boson* got its mass

symmetry: not just a magazine.

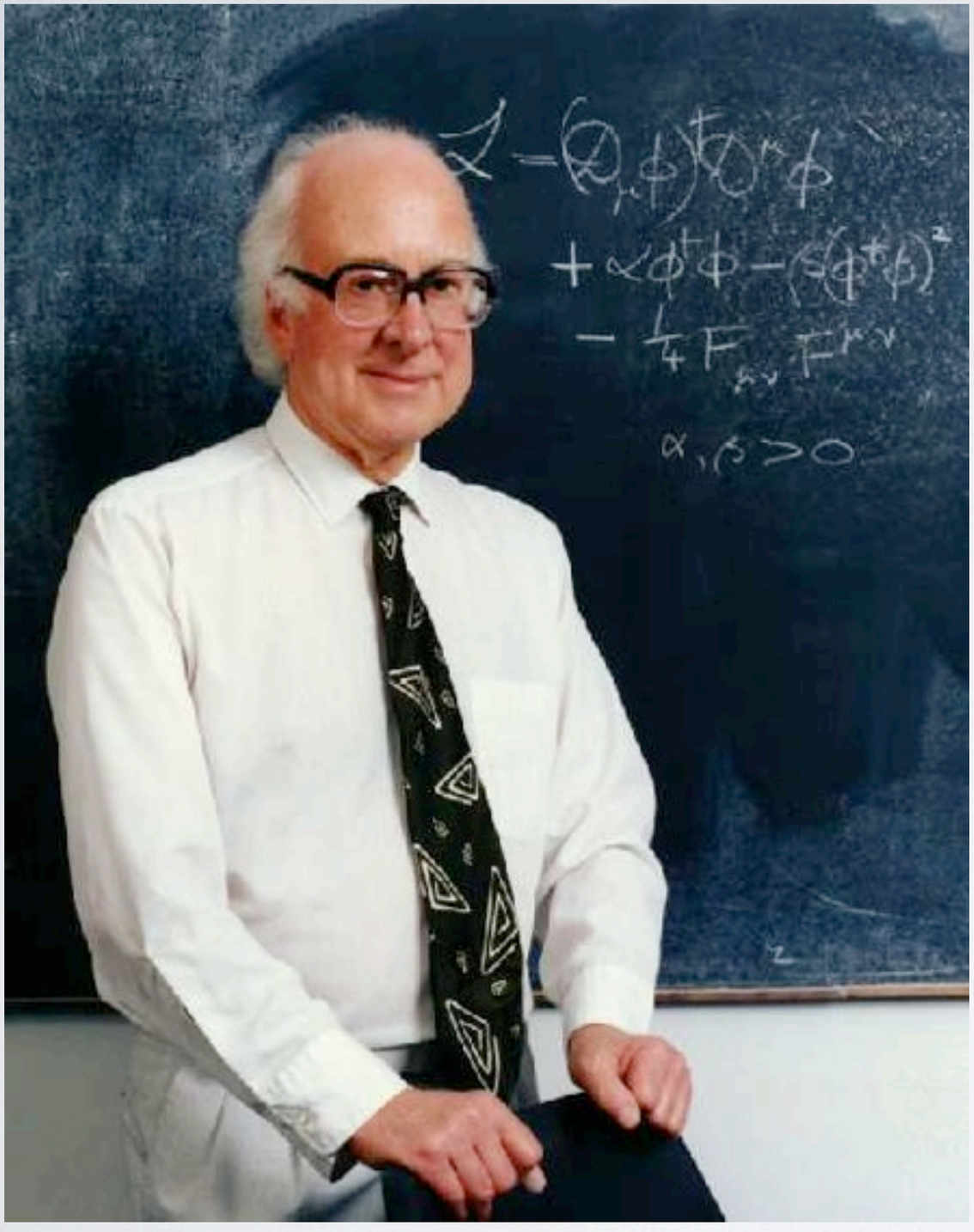
Symmetries of nature tell us about interactions and particles

But, they predict all the gauge bosons are massless, like the photon...a very different world from our's

Spontaneous symmetry breaking,
the **Higgs mechanism**

*and all elementary particles

Higgs: the man, the mechanism and the particle



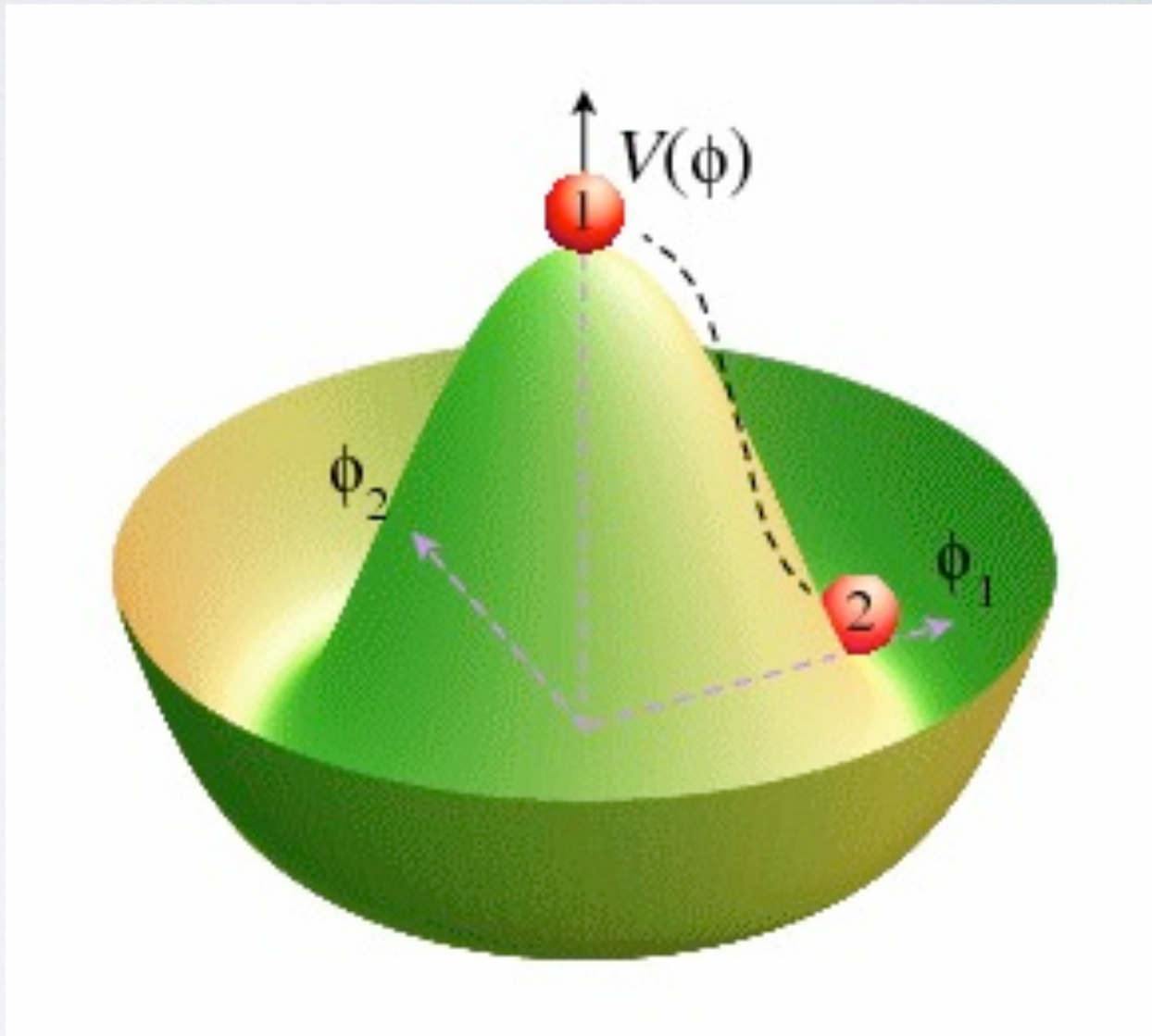
The man

The other men
(Kibble, Guralnik, Hagen, Englert, Brout)

Higgs: the man, the mechanism and the particle

Spontaneous symmetry breaking

Laws of nature are symmetric, our world has that symmetry hidden. Broken symmetry



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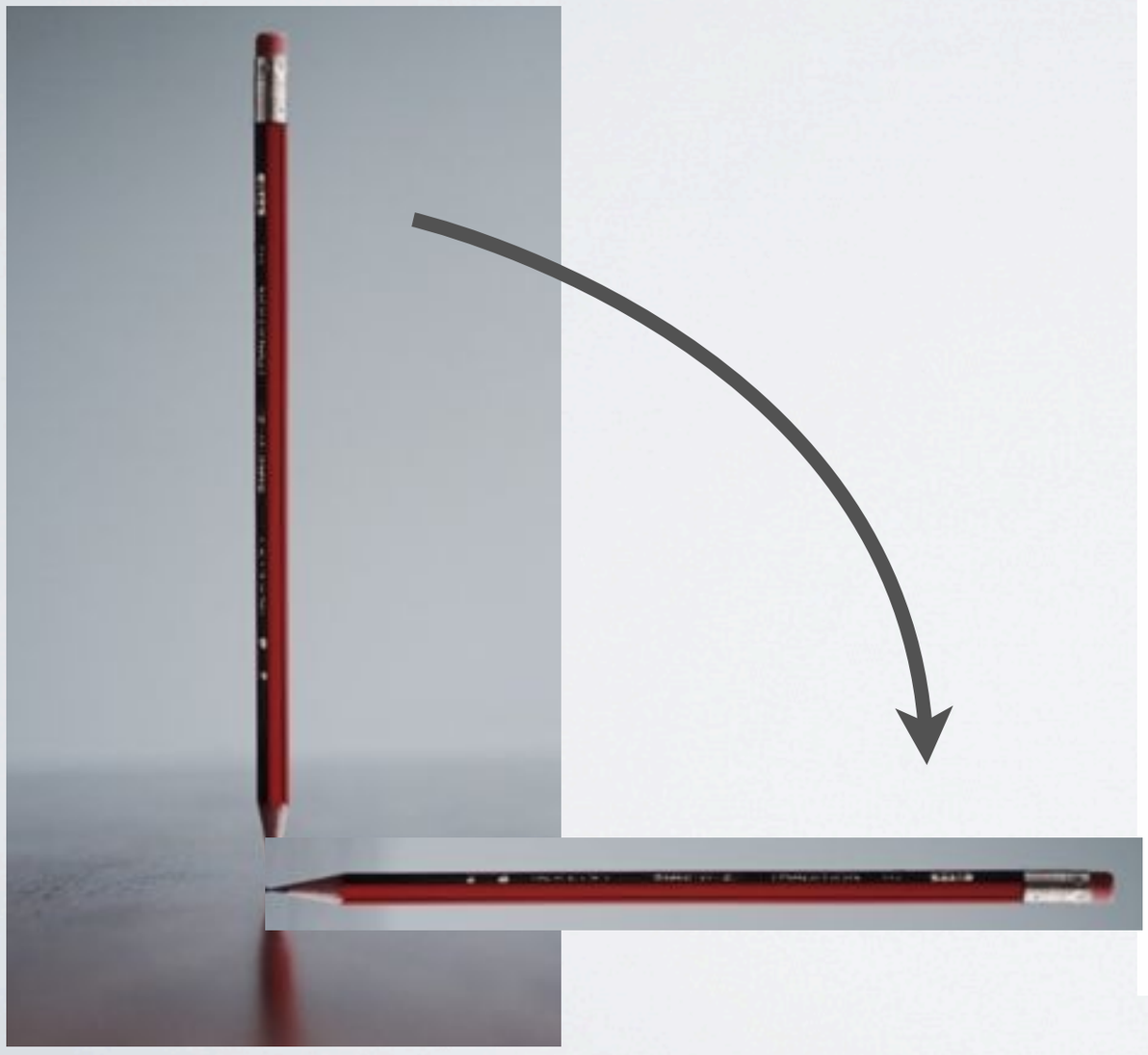

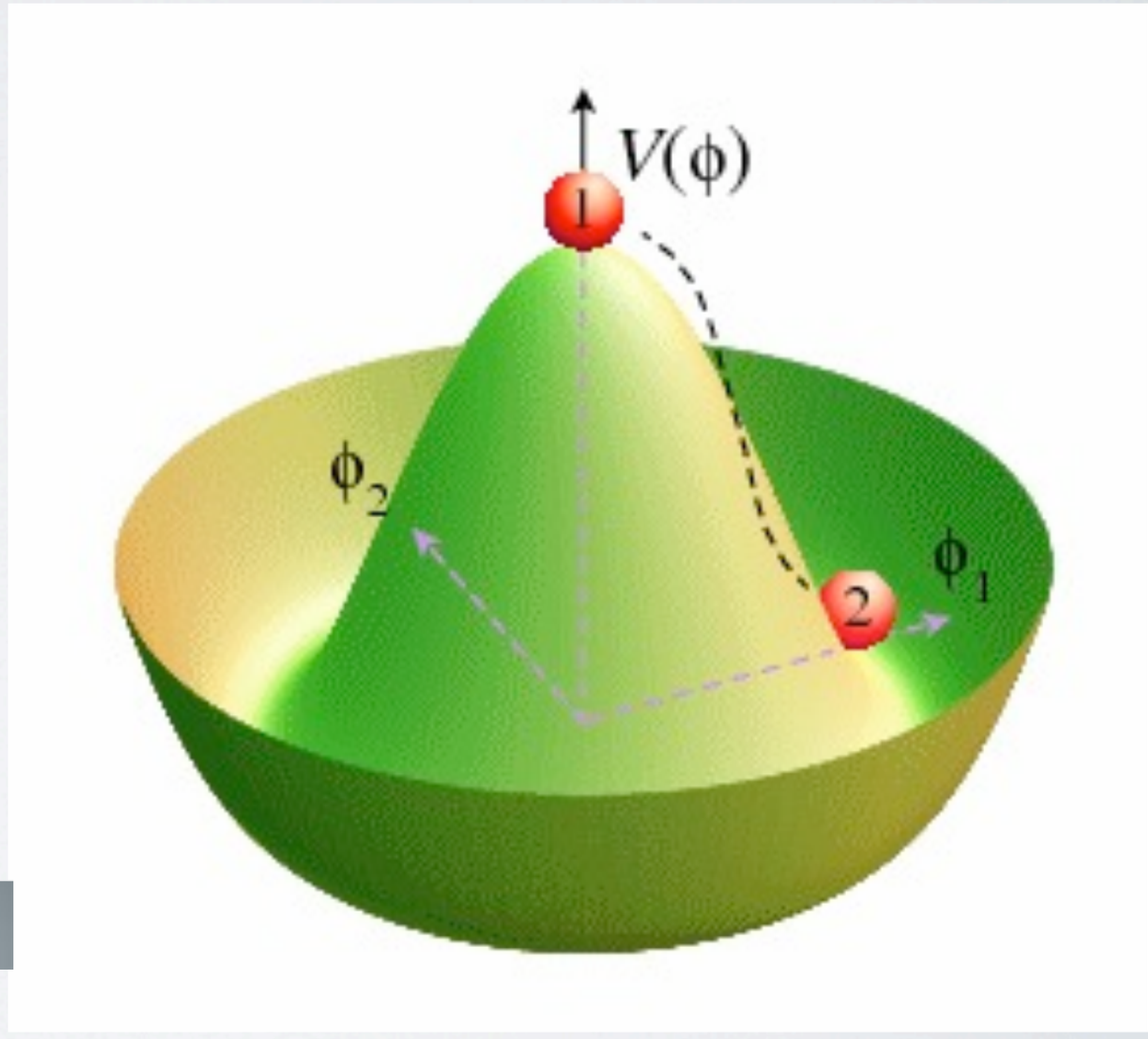

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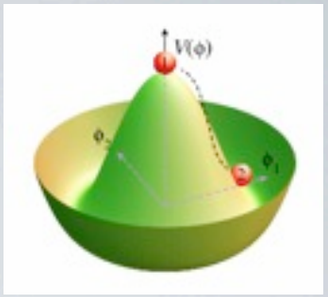
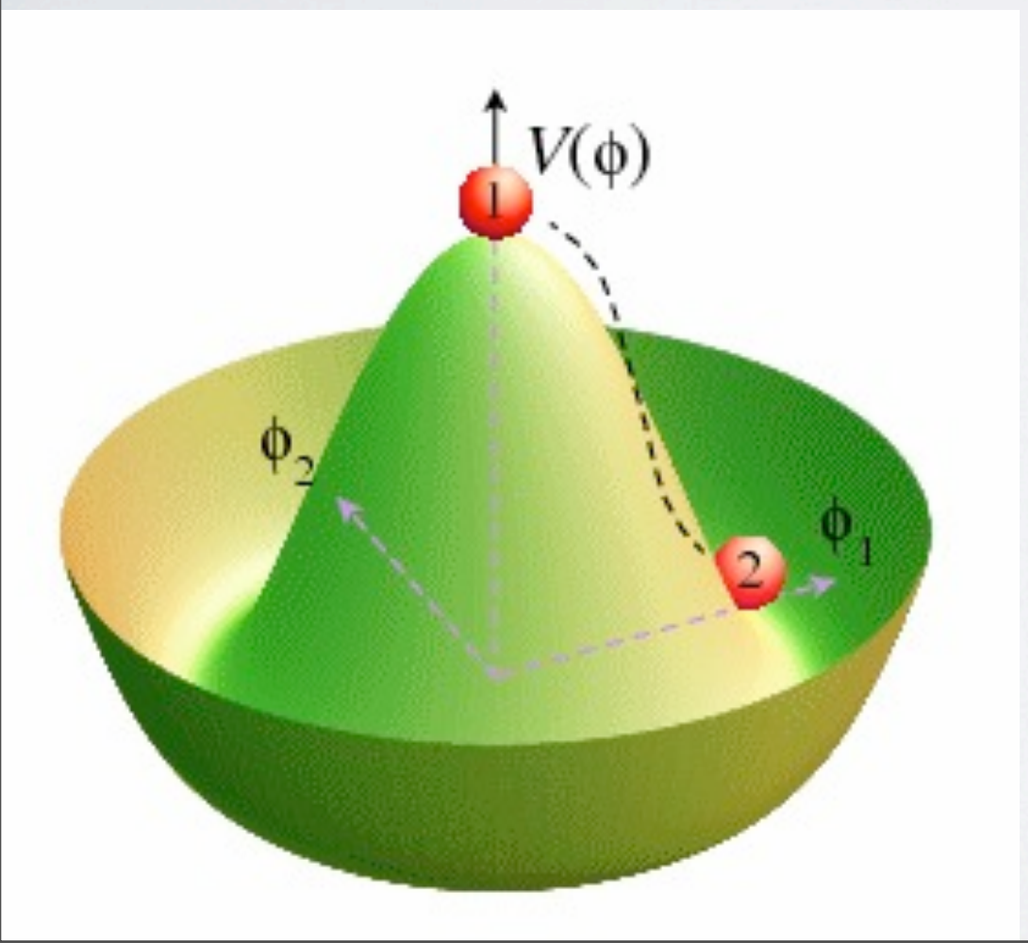


The return of the aether

The Higgs has a "vacuum expectation value" (vev)
Coupling of other particles to the Higgs (and its vev) give them mass
The bigger the mass the bigger the coupling

Higgs: the man, the mechanism and the particle



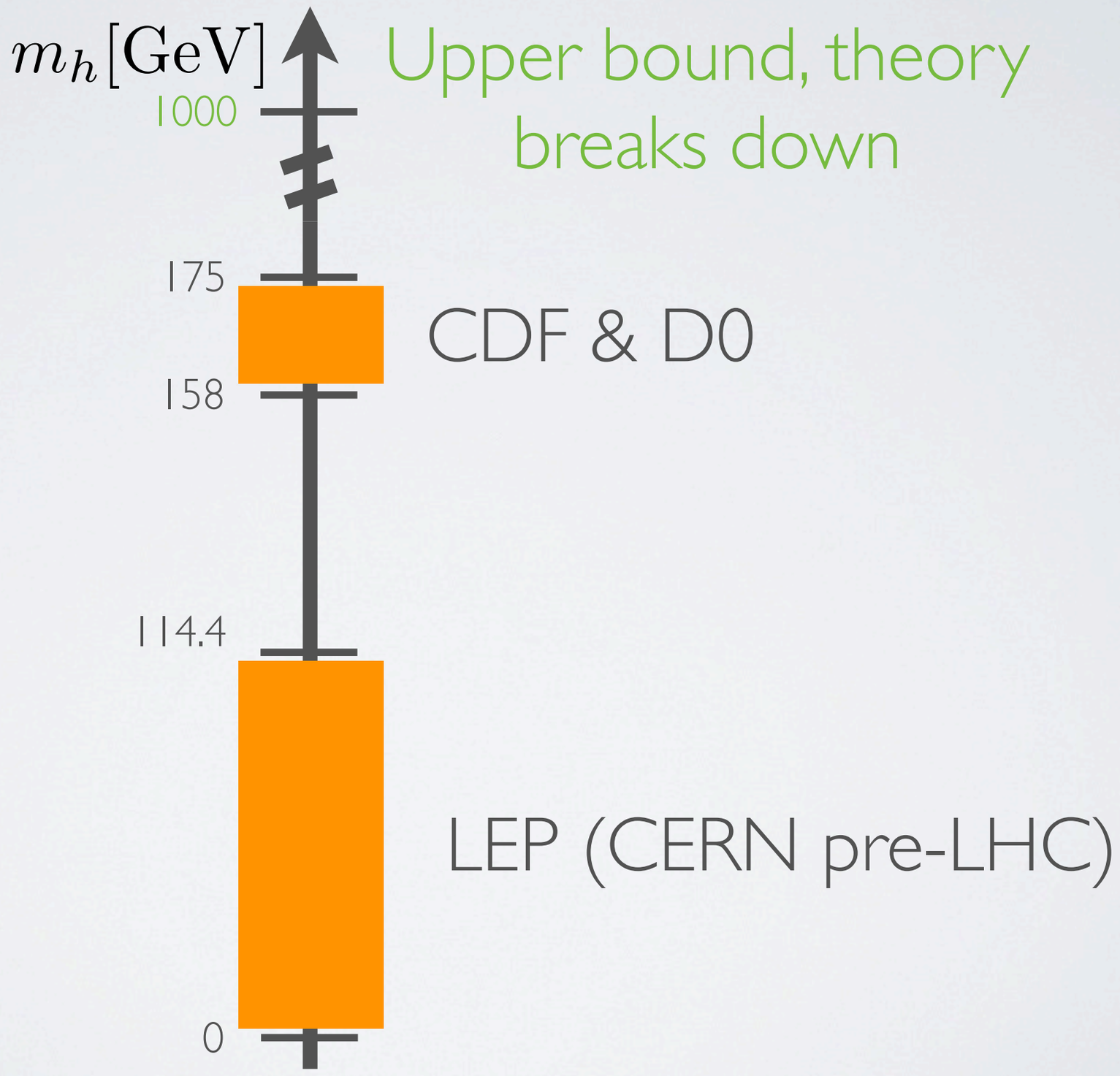
The Higgs boson

Sole remaining piece of the Standard Model

Guaranteed to see it, or something like it, at Tevatron or LHC

What do we know about the Higgs?

Couples to mass -- determines how it is made and how to look for it



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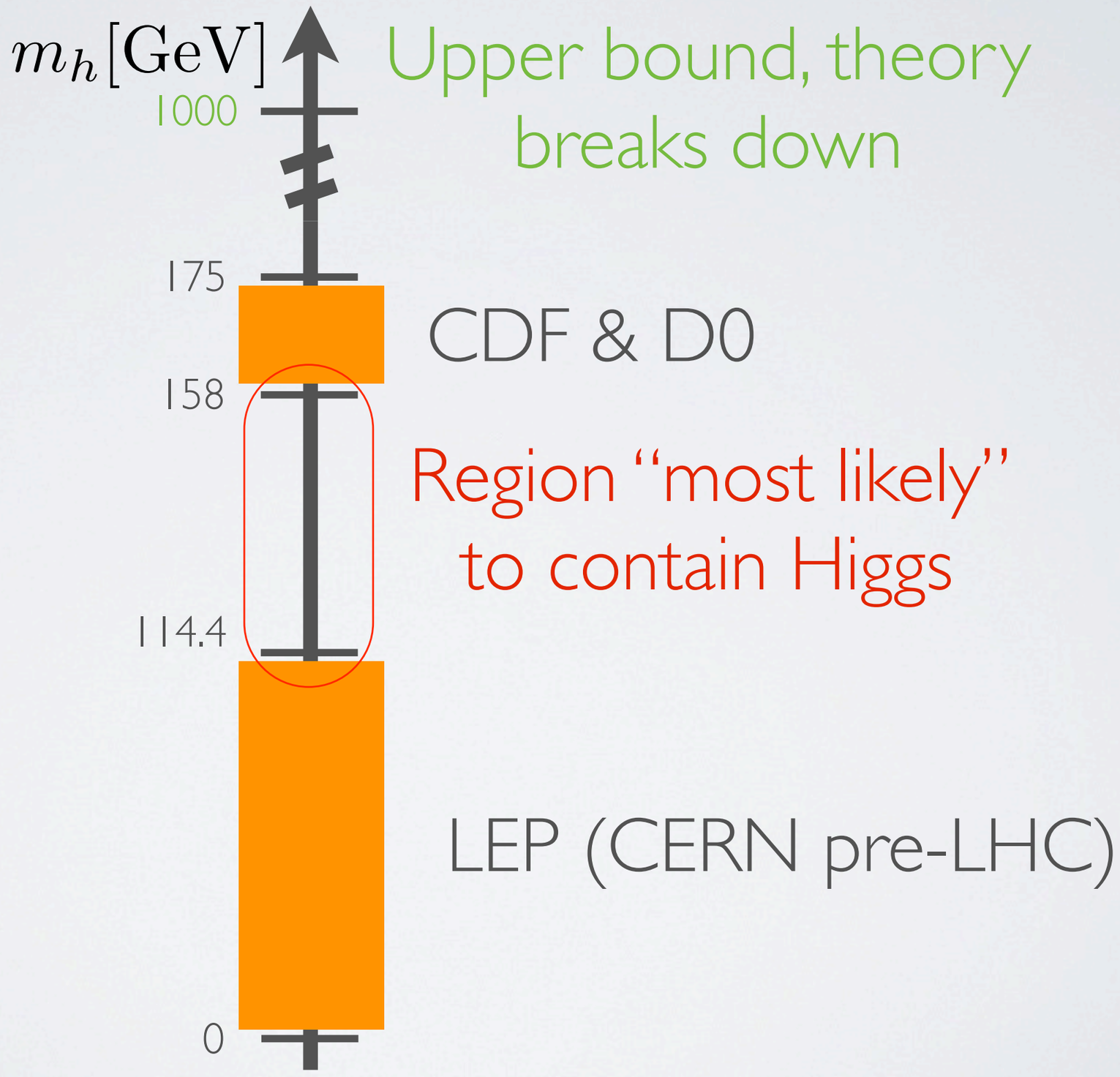

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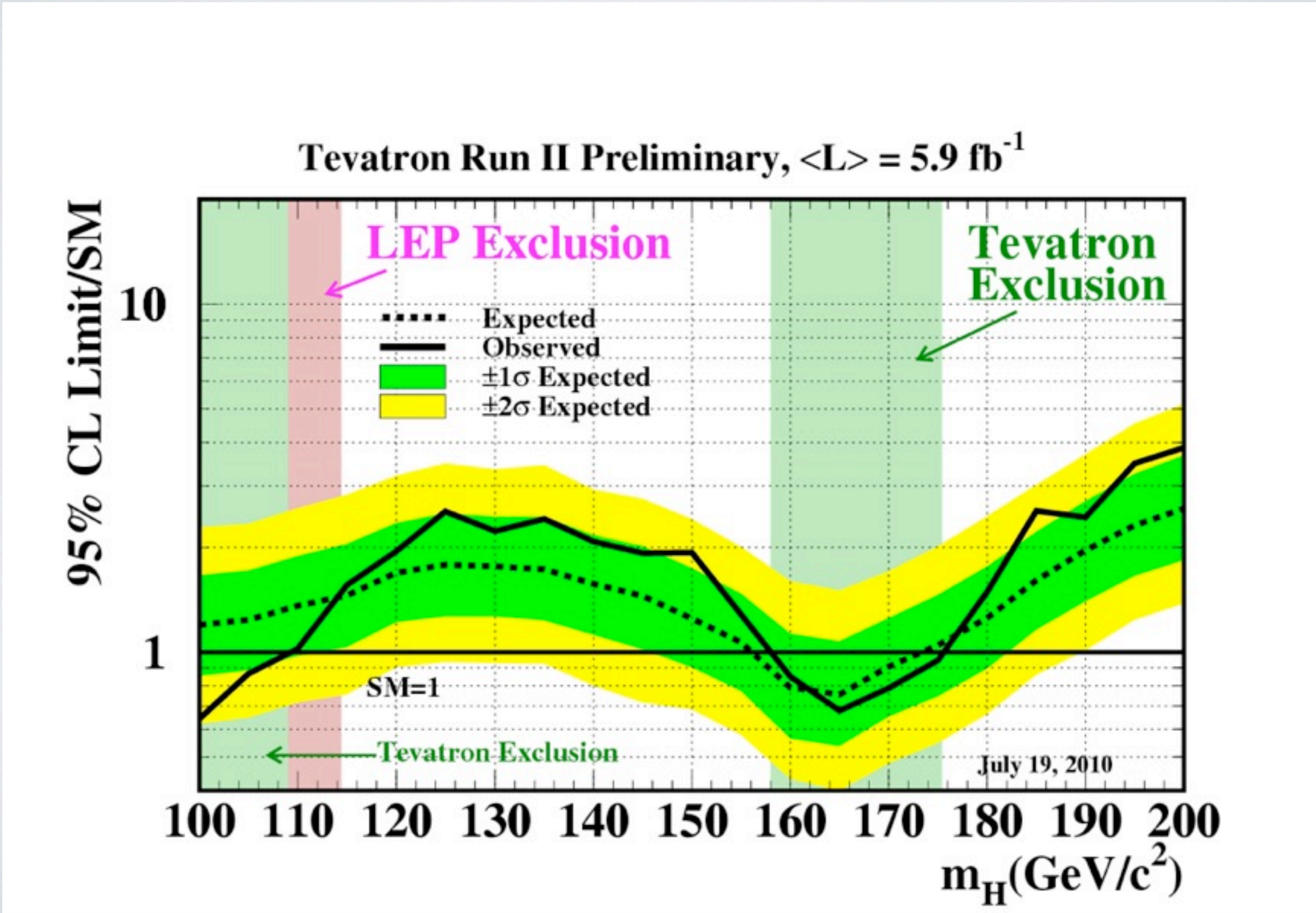
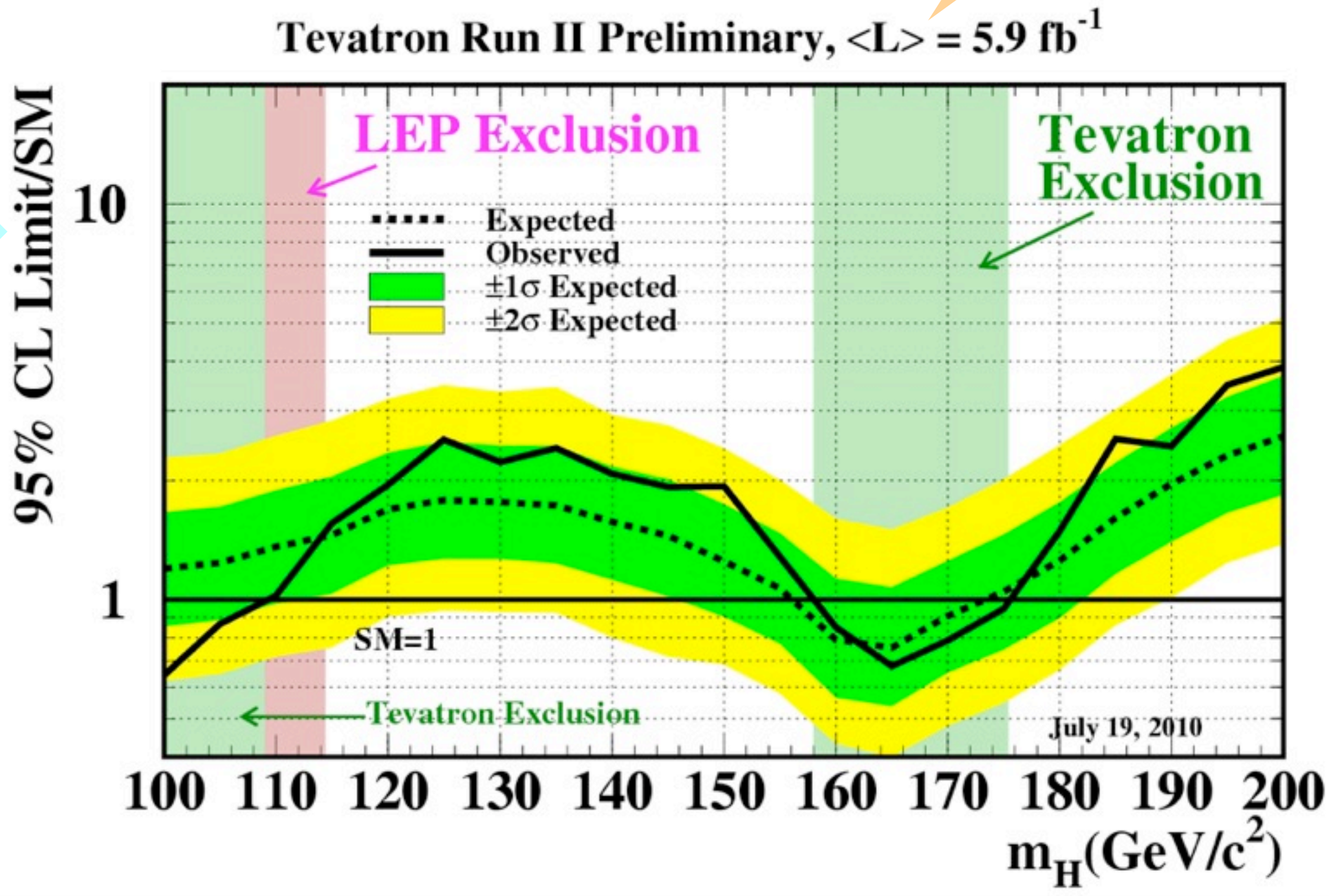


What do we know about the Higgs?

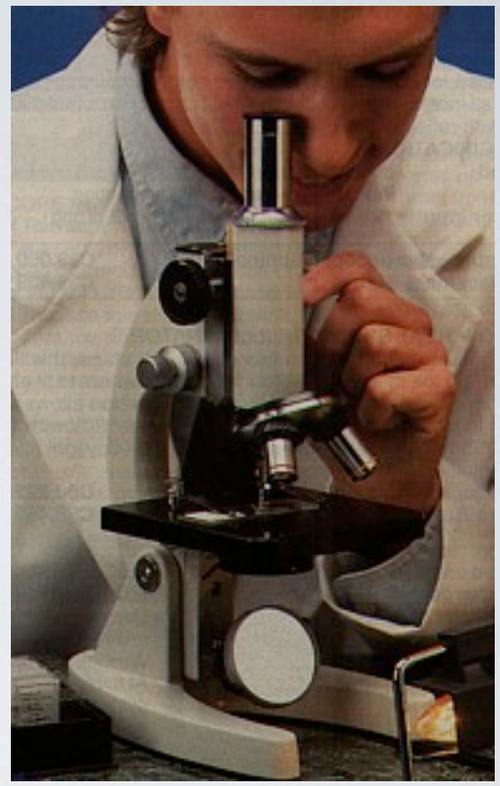
Couples to mass -- determines how it is made and how to look for it

"amount of data" ~0.5 x what has been collected so far

95% confidence limit relative to the standard model

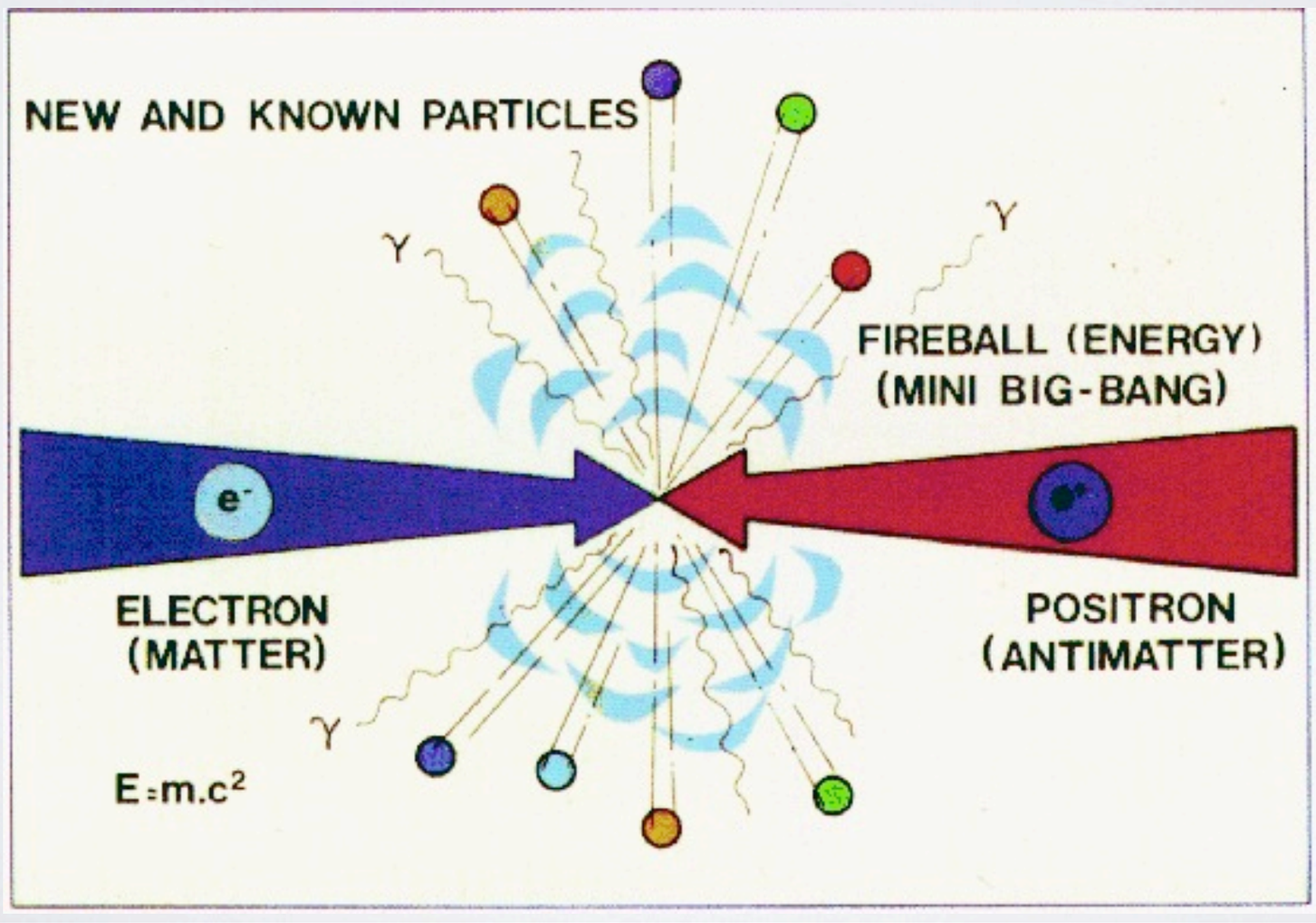


Q: How do you search for the Higgs boson? (hint: $E = mc^2$)



The Higgs is heavy, lives for a very short time, doesn't exist in nature

Need to look at very small distances



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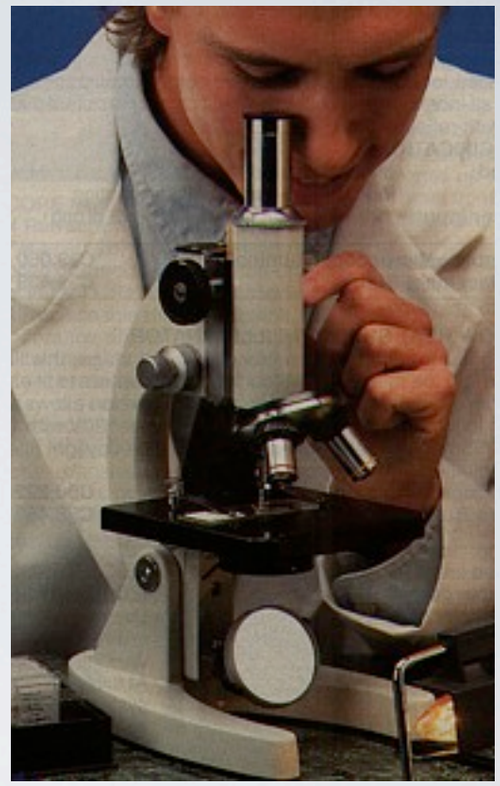
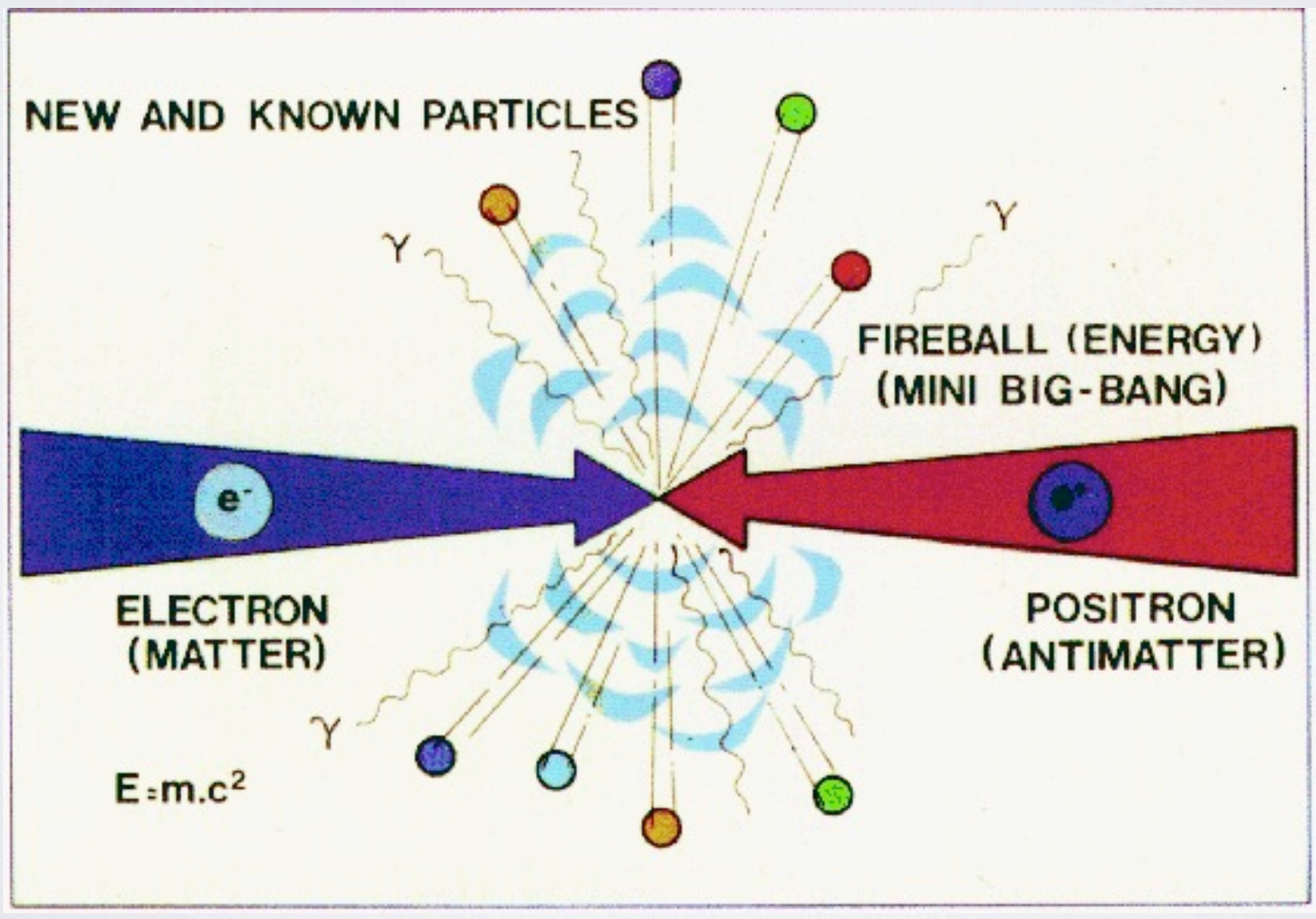
Experimental physicist in the lab →





Q: How do you search for the Higgs boson?

FERMIONS
matter constituents
spin = 1/2, 3/2, 5/2, …

Leptons spin =1/2

Flavor	Mass GeV/c^2	Electric charge
ν_L lightest neutrino*	$(0–0.13)\times10^{-9}$	0
e electron	0.000511	–1
ν_M middle neutrino*	$(0.009–0.13)\times10^{-9}$	0
μ muon	0.106	–1
ν_H heaviest neutrino*	$(0.04–0.14)\times10^{-9}$	0
τ tau	1.777	–1

Quarks spin =1/2

Flavor	Approx. Mass GeV/c^2	Electric charge
u up	0.002	2/3
d down	0.005	–1/3
c charm	1.3	2/3
s strange	0.1	–1/3
t top	173	2/3
b bottom	4.2	–1/3

BOSONS
force carriers
spin = 0, 1, 2, …

Unified Electroweak spin = 1

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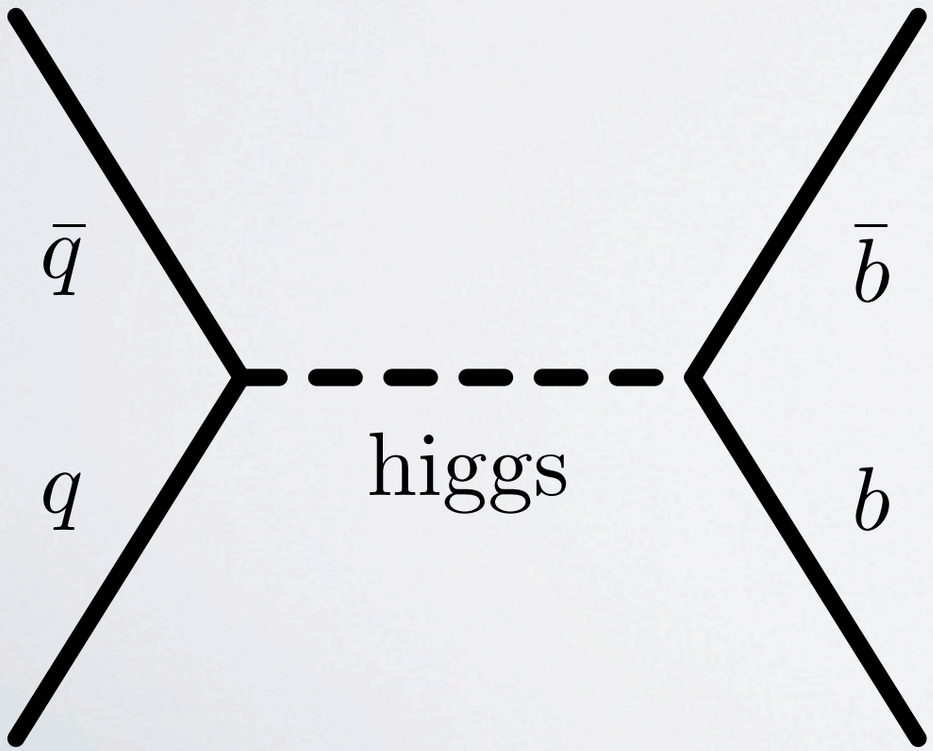
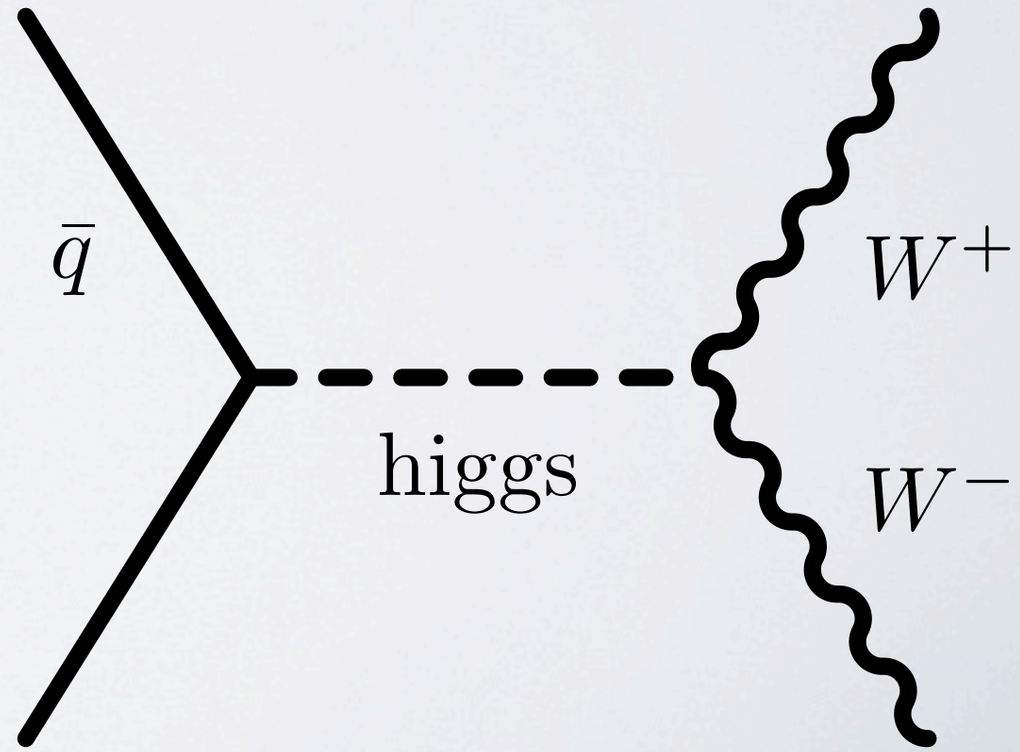
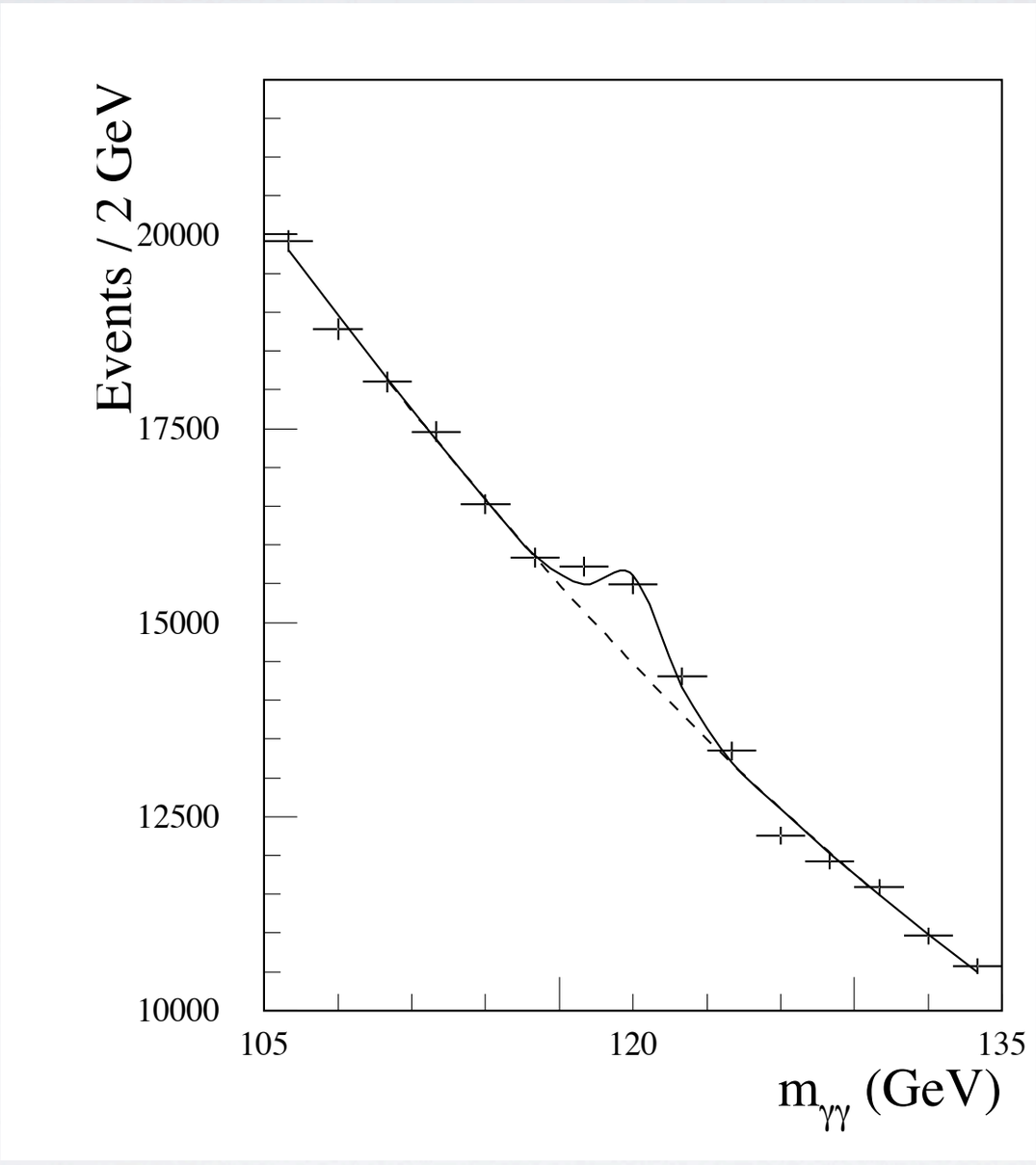




Searching for the Higgs boson

Higgs production is a rare process

Worse yet, its decay products can look like mundane events



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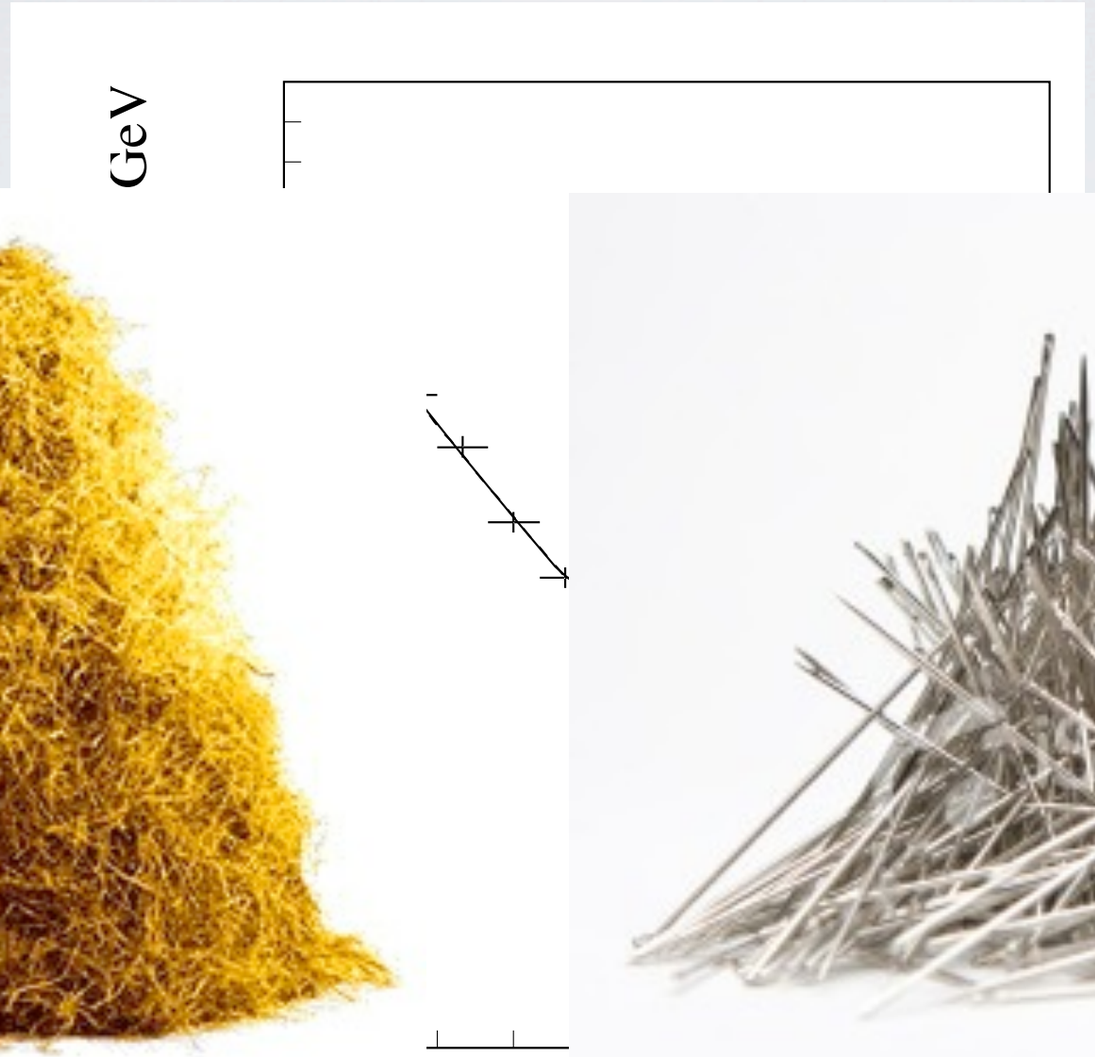

CERN and Fermilab - competitive collaboration

Ultimately LHC will have ~7x Tevatron's energy
Aids in discovering Higgs (and other new physics)
Tevatron collides $p\bar{p}$ and LHC collides pp

Two machines complementary in approach and capabilities

Discovering the Higgs, and proving it is the Higgs is a long process, multiple sources of information are key

"Watching CERN discover the Higgs would be like watching your mother-in-law drive over a cliff.....

Leon Lederman

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Aids in discovering Higgs (and other new physics)
Tevatron collides $p\bar{p}$ and LHC collides pp

Two machines complementary in approach and capabilities

Discovering the Higgs, and proving it is the Higgs is a long process, multiple sources of information are key

"Watching CERN discover the Higgs would be like watching your mother-in-law drive over a cliff.....

....in your Mercedes!"

Leon Lederman

Questions?